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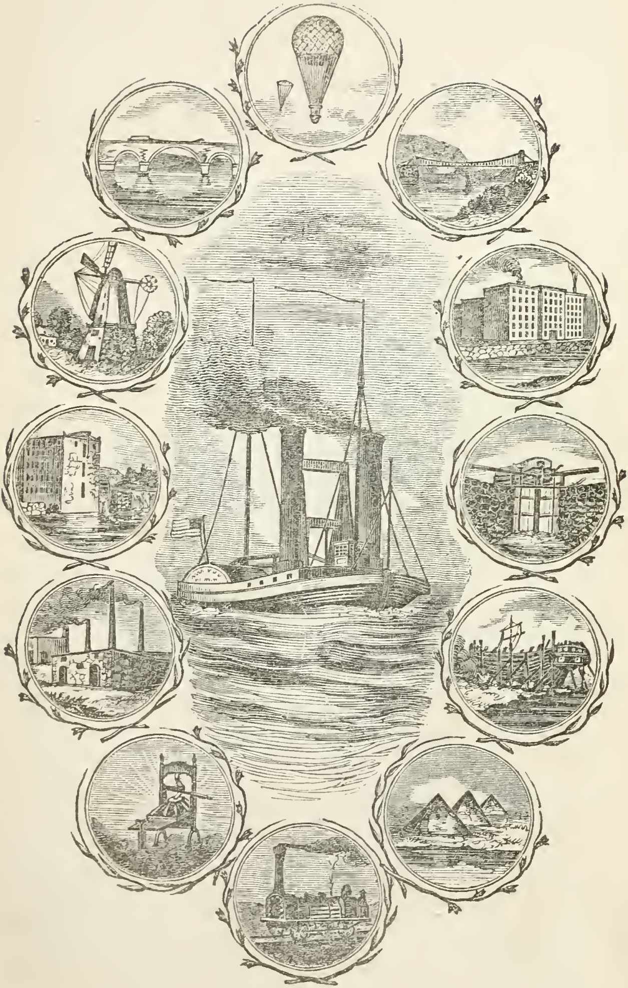

MEMOIRS

OF THE

MOST EMINENT

AMERICAN MECHANICS:

ALSO,

LIVES OF DISTINGUISHED EUROPEAN MECHANICS;

TOGETHER WITH A COLLECTION OF

ANECDOTES, DESCRIPTIONS, &c. &c.

RELATING TO THE MECHANIC ARTS.

ILLUSTRATED BY FIFTY ENGRAVINGS

BY HENRY HOWE.

"The due cultivation of practical manual arts in a nation, has a greater tendency to polish and humanize mankind, than mere speculative science, however refined and sublime it may be."

NEW-YORK:
J. C. DERBY, No. 119 NASSAU STREET.
CINCINNATI: H. W. DERBY.
CHICAGO: D. B. COOK & CO.
1856.

PREFACE.

It is singular that so little interest should heretofore have been taken in the history of those to whom we are indebted for the arts and inventions constituting the glory of our time. The pen has ever been more ready to record the brilliant than the useful To this is to be attributed the neglect heretofore manifested in relation to these subjects. Indeed, so little regard has been evinced, that a late foreign writer, who happened incidentally to be "thrown upon" some incidents in the life of an eminent mechanician, considered it due to the fastidiousness of public taste, to claim indulgence for diverging into so obscure and tasteless a path of biographical research. But, thanks to the more general diffusion of knowledge and the light of Christianity, this false taste is rapidly dissipating, and mankind are beginning to appreciate the labors of those to whom we are indebted for our present unparalleled state of intellectual and social advancement.

The memoirs of the benefactors of our race, in past ages, are often histories of wrong; and those who have labored in the department of mechanical invention, may truly be termed the *martyrs of civilization!* The causes producing this state of

things are fading away before the intelligence of the times, and wise and just laws are in operation to protect the defenceless. As has been aptly observed, " the strife of trade has superseded the strife of war,"—the clash and din of arms has given place to the busy hum of industry, the ringing of the anvil, the melody of the waterfall, and the puff of the steam engine. The days of tournaments are past,—the mechanic fairs are our " tilting grounds," where the conflict is not for physical superiority, but for inventions best promoting the comfort and elegance of life. Although much has been done, more remains to be accomplished. This new world is to be a theatre of mighty structures for the development of resources, advancing, beyond present conception, the welfare and happiness of our race

Biographies of public individuals have their peculiar advantages; but examples drawn from the common walks prove of more practical utility. Such are here presented; and it is judged that their perusal will be found at least as useful as tracing the progress of a military hero through scenes of blood, or witnessing the more peaceful triumphs of some champion in the field of political strife.

With these views we have prosecuted this undertaking, in the hope of producing a series of memoirs, which, while of general interest, would be *useful* to the mechanic: and the aim being to give as much variety as possible within our assigned limits, we have reluctantly excluded several characters, who, but for their similarity of pursuit, would have adorned our pages.

The materials are drawn from a variety of sources; but we are principally indebted to the various mechanical journals of the day, including the publications of the Society for the Diffusion of Useful

Knowledge. Most of the memoirs, however, in the American department were written expressly for the work, while several of the others in this as well as in the other portion have undergone more or less modification.

To those who have kindly furnished us with notices of their respective friends, we feel duly grateful. To the public we present the result of our labors, with the desire that it may excite emulation, and illustrate and encourage the talent and perseverance required for a successful cultivation of the mechanic arts.

H. H.

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AMERICAN MECHANICS.

JOHN FITCH,

AN EARLY STEAMBOAT INVENTOR

"The invention all admired, and each how he
To be the inventor missed; so easy it seemed,
Once found, which yet unfound, most would have thought
Impossible." MILTON.

Who invented the first steamboat?—Early experimenters in steam—Blasco de Garay.—Jonathan Hulls.—Fitch's manuscript.—Birth.—Character of his parents.—Loses his mother.—Juvenile heroism.—Mother-in-law.—Schoolboy days.—Becomes a great arithmetician.—Father's austerity.—Hears of a *wonderful* book.—Great thirst for knowledge.—Self-denial and industry.—Makes a purchase.—Becomes a great geographer.—Father purchases him scale and dividers.—Great joy thereat.—Studies surveying.—Surveys with the governor, and paid in glory.—Leaves school for the farm.—Brother's tyranny.—Desires to study astronomy.—Relaxes from studious habits.—Embarks as a cabin-boy in a coaster.—Cruel treatment.—Leaves, and enters another.—Makes a short voyage.—Returns.—Accidental meeting with a clockmaker.—Wishes to enter his service.—Selfish opposition of his parents.—Kindness of his brother-in-law.—Enters the clockmaker's service.—His neglect.—Leaves in ignorance of his profession.—Enters the service of a clockmaker and watch repairer.—Gross injustice.—Leaves.—New employment, and success.—A change, and misfortune.—Marries.—Unhappy life.—Abandons his wife.—Wanders.—Visits the Jerseys.—Sickly appearance a prevention to obtaining employment as a day-laborer.—Turns button-maker.—Revolutionary war.—Repairs arms for the continental army.—Employed in Kentucky as a surveyor.—Taken prisoner by the Indians, and carried into captivity.—Release.—Returns to the east.—First idea of a steamboat.—Curious reflections.—Dr. Thornton's account of his experiments.—*Note.*—Biographical Sketch of Rumsey.—Description of Fitch's boat.—Goes out to France.—Return.—Misfortunes.—Generosity of a relation.—Visits Kentucky.—Better prospects.—Death.

"WHO invented the first steamboat?" is a question which has excited great controversy,—an achievement of which nations as well as individuals have been covetous.

Several of the early experimenters in steam appear to have conceived of the idea. The first account we have on the subject is given in a work recently published in Spain, containing original papers relating to the voyage of Columbus, said to have been pre-

served in the royal archives at Samancas, and among the public papers of Catalonia and those of the secretary at war for the year 1543. This narrative states that "Blasco de Garay, a sea captain, exhibited to the emperor and king Charles V., in the year 1543, an engine by which ships and vessels of the largest size could be propelled, even in a calm, without the aid of oars or sails. Notwithstanding the opposition which this project encountered, the emperor resolved that an experiment should be made, as in fact it was, with success, in the harbor of Barcelona, on the 17th of June, 1543. Garay never publicly exposed the construction of his engine, but it was observed at the time of his experiment, that it consisted of a large caldron or vessel of boiling water, and a moveable wheel attached to each side of the ship. The experiment was made on a ship of 209 tons, arrived from Calibre, to discharge a cargo of wheat at Barcelona; it was called the Trinity, and the captain's name was Peter de Scarza. By order of Charles V. and the prince Philip the Second, his son, there were present at the time, Henry de Toledo, the governor, Peter Cardona, the treasurer, Ravago, the vice-chancellor, Francis Gralla, and many other persons of rank, both Castilians and Catalonians; and among others, several sea captains witnessed the operation, some in the vessel, and others on the shore. The emperor and prince, and others with them, applauded the engine, and especially the expertness with which the ship could be tacked. The treasurer Ravago, an enemy to the project, said it would move two leagues in three hours. It was very complicated and expensive, and exposed to the constant danger of bursting the boiler. The other commissioners affirmed, that the vessel could be tacked twice as quick as a galley served by the common method, and that at its slowest rate it would move a league in an hour. The exhibition being finished, Garay took from the ship his engine, and having deposited the wood work in the arsenal of Barcelona, kept the rest to himself. Notwithstanding the difficulties and opposition thrown in the way by Ravago, the invention was approved; and if the expedition in which Charles V. was then engaged had not failed, it would undoubtedly have been favored by him. As it was, he raised Garay to a higher station, gave him a sum of money (200,000 maravedies) as a present, ordered all the expenses of the experiment to be paid out of the general treasury, and conferred upon him other rewards."

The editor of the Franklin Journal, from which this extract has been made, observes, "when the 'Public Records' shall appear in an *authentic form*, their evidence must be admitted; *until then* he should not be inclined to commence the history of the inven-

tion of the steamboat so far back as 1543. For circumstantial as the account is, it seems to have been written since the days of Fulton."

He is not alone in this opinion, as it is universally regarded as a mere fiction, the offspring of an individual jealous of his country's reputation.

The most prominent and authentic account of the early projects of applying steam as a motive power to the propelling of vessels, is given in a treatise printed in London in 1737, entitled "Description and draught of a new-invented machine, for carrying vessels out of, or into any harbor, port, or river, against wind and tide or in a calm: for which his majesty George II. has granted letters patent for the sole benefit of the author, for the space of fourteen years; by Jonathan Hulls." The draught or drawing prefixed is a plate of a stout boat with chimney smoking, a pair of wheels rigged out over each side of the stern, moved by means of ropes passing round their outer rims; and to the axis of these wheels are fixed six paddles to propel the boat. From the stern of the boat a tow-line passes to the foremast of a two-decker, which the boat thus tows through the water. There is no evidence that Hulls ever applied his conceptions to practice.

Since that time, down to the period of the great and successful experiments of Fulton, several attempts were made here and in Europe, with varied success. Among the most, if not the most conspicuous, were those made by the subject of this article.

A few years previous to his death, Fitch prepared a memoir of himself, including a history of his experiments in steam. These papers were bequeathed to the Franklin Library of Philadelphia, with directions that they should be unsealed and perused thirty years from the time of his decease. At the appointed period they were opened, and found to contain a very full account of his life, particularly of that portion which related to his experiments in steam, including the progress of his operations from the time the thought first occurred to him, until the completion of the boat so far as to make numerous experiments on the Delaware,—the subsequent alterations made, and the final abandonment of the scheme by the original stockholders.

These manuscripts show but one tissue of discouragements and perplexities, and prove him to have been a strong-minded but unlettered man, with a perseverance almost unexampled, and a determination to let no difficulty in the execution of his plan prevent him from endeavoring to bring it to perfection, so long as the shareholders furnished the means of defraying the expenses. Indeed, disappointment and oppression appear to have borne him

company from his very youth; and, as he himself remarks, it is the history of one of the most "*singular*," as well as one of the most "*unfortunate men in the world!*"

From this narrative we shall make liberal quotations, especially from that portion relating to his younger days. It is the incidents of youth that give a tone and direction to character. We can all of us refer to some of the most apparently trivial events of earlier years that have completely changed the whole current of our thoughts and pursuits. In the memoir before us there can be traced, with a minuteness uncommon even in biography, those circumstances which moulded his strong mind into its peculiar model; and we can there perceive the origin of that misanthropical cast of thought,—that eccentricity of character and that looseness of sentiment in regard to concerns of a serious nature, which so strongly marked the author of its pages.

This memoir is addressed to the "worthy Nathaniel Irwin, of Neshamoney," in Pennsylvania, a clergyman and a gentleman of whose talents and kindness of disposition Fitch had formed the highest estimate, and who, it appears, once requested him to prepare something of the kind. The principal reason which Fitch gives for complying with this request was, that his life had been filled with such a variety of changes, affording such useful lessons to mankind, that he considered it a neglect of duty were he to suppress it.

"The 21st of January, 1743, old style," says he, "was the fatal time of bringing me into existence. The house I was born in was upon the line between Hartford and Windsor (Connecticut.) It was said I was born in Windsor;* but from the singularity of my make, shape, disposition, and fortune in the world, I am inclined to believe that it was the design of Heaven that I should be born on the *very line*, and not in any township whatever; yet am happy also that it did not happen between two states, that I can say I was born somewhere."

Fitch's father was a farmer in good circumstances. His besetting sin seems to have consisted in a want of generosity in pecuniary affairs,—so much so that his son observes, "I presume he never spent five shillings at a tavern during the whole course of his life." This, in our day, would be considered as a very singular and inapt illustration of that trait of disposition; but when we remember the customs of society at that period, and the total deprivation of every thing like "amusement," inseparable from the isolated condition of agriculturists, we shall comprehend some-

* Now East Windsor.

thing like the spirit of the allusion. Still, his parent appears to have been a good provider; for he goes on to state, "we always had plenty of victuals and drink in the house. In the whole course of my acquaintance with him, I never knew him out of cider but about two weeks, and never out of pickled pork. Our victuals were coarse, but wholesome, such as pork and beans, codfish and potatoes, hasty pudding and milk," and, what was particularly valued, "always a stout hasty pudding after dinner." His parents had five children, two sons and two daughters, besides the "*unfortunate John.*"

"From the time of my birth," says he, "until I was five years of age, nothing material happened to me that I can recollect, any more than crawling along the floor and picking ants out of the cracks, and now and then catching a fly, which made as lively impression on my mind, as great, perhaps, as the Trojan war on the minds of heroes."

"When I was four years old I went to school: I know from the circumstance that my mistress used to ask me how my mother was, and she died when I was five years old. I recollect that I learned to spell the first summer before my mother's death, whilst I went to Mrs. Rockwell. I remember frequently spelling there without the book the words commandment, Jerusalem, &c. But soon the fatal day arrived when my mother's guardianship should be taken from me, and early in the fall I was deprived of her. Although I did not consider my loss, natural affection carried my griefs to a very great excess for a child of my age." He here, and frequently elsewhere, speaks of his mother with regard, and no doubt her loss proved injurious to him. She was a kind and affectionate woman, without those disagreeable traits which marked the character of his other parent.

"When about six years of age," he remarks, "a most extraordinary circumstance happened to me, worthy of the notice of a Roman soldier." Returning from school about dusk one day, he found no one in the house except a little sister, his second brother being in the barn yard holding a "wicked cow" for his eldest sister to milk. This little sister being anxious to show him a present which she had received during the day, it being too dark to see without, lighted a candle to find it. Unfortunately, in her search she set fire to two large bundles of flax standing in a distant corner of the room, which young Fitch no sooner observed, than, with a presence of mind truly wonderful in a child so young, he ran and seized one of the blazing bundles, which was more than he was enabled to lift without resting it upon his knees, carried it to the hearth, and threw it down. In so doing he blistered his

hands and set his hair in a blaze, but, smothering the fire on his head with his naked hands, he sprang and grasped the other bundle and brought it to the same place, blistering his hands and setting his head on fire the second time, and putting it out in like manner. Having done this, he jumped upon the bundles until the fire was extinguished. "In the mean time," he says, "whilst I was thus occupied, my little sister Chloe being frightened, ran to the barn yard, and probably told my brother some improper story. When I had the fire put out, notwithstanding my painful hands and smarting face, which was then covered with blisters, I went to relate the tale to my elder brother; but no sooner did I arrive in the yard than he fell foul of me, boxing my ears and beating me beyond reason for the greatest fault, and would not give me leave to say a word in my behalf. As my father had that evening gone a courting, I had nowhere to apply to for redress, therefore was obliged not only to submit to the greatest indignities, but to the greatest injustice. On his return I made complaints, but without satisfaction or redress. This being what I may call the first act of my life, seemed to forebode the future rewards that I was to receive for my labors through it, which has generally corresponded with that."

When he was about seven years old, his father married "one Abigail Church," whom he describes as being an orderly, easy-tempered old maid of forty, possessing sense sufficient to manage the affairs of the house.

"My father," he continues, "kept me constantly at school until I was eight or nine years of age, as my schooling cost him *nothing*. When the weather was too bad to go to school, he had goodness enough to encourage my learning my book at home, and would frequently teach me. Before I was ten years old I could say the New England Primer all by heart, from Adam's fall to the end of the catechism. But the most surprising thing of my learning appears to me to be this: My father had an old arithmetic book in the house, by one Hodder, with the old-fashioned division in it. I was able at nine years of age to make figures pretty well, as well as to write a legible hand. Whenever I had a minute's leisure I would have that book in my hand, and learned myself out of it the true principles of addition, subtraction, multiplication, and division; and the year that I was nine years of age, could tell how many minutes old I should be when I should have seen ten years, but was not able to multiply the figure nine: this I did in the presence of four or five neighbors one rainy day, to their admiration. When about eight years of age, my father took me from school, and set me to work in the most serious and diligent

manner, although I was exceedingly small of my age, and scarcely able to swingle more than two pounds of flax, or thresh more than two bushels of grain, with the steadiness of a man of thirty years for that trifling, pitiful labor. I was prevented from going to school more than one month in the winter, when he saw that I was nearly *crazy* after learning, and then I was always obliged to leave before it was out to come home to help him fodder."

"My father was one of the most strenuous of the sect of Presbyterians, and a bigot, which he carried to such excess that I dare not go into the garden to pick currants or into the orchard to get apples on the sabbath. I really believe that he thought it the extent of his duty toward me to learn me to read the Bible, that I might find the way to heaven; when he had done that he felt perfectly easy, and if I could earn him twopence per day it ought not to be lost. It may be irreverent for me thus to speak as I have done of a parent, but I mean to communicate the truth to you, and in as particular a manner as I can." Without apologizing for the unnatural language of Fitch in thus speaking of a parent, we can perceive in that austerity and scrupulous observance of the mere outward forms of religion which he evinced, without being sufficiently guided by its true spirit to act generously and fairly by those around him, the origin of that infidelity of sentiment which formed so striking a feature in the character of his son.

"But notwithstanding," continues Fitch, "he suppressed me from going to school, he did not hinder me from studying such books as he had; and at noontimes and evenings, instead of playing, as is common with boys of that age, I was as studious as the most zealous student under the eyes of a tutor, and, in particular, in Hodder's Arithmetic, which went as far as Alligation Alternate. When I was eleven years old, I *heard* of a book that would give me a knowledge of the *whole world*, which was Salmon's Geography. I repeatedly requested my father to get it for me, but to no purpose. I then proposed to him to give me some headlands at the end of a field to plant potatoes, which he granted, and I dug it up by hand on a holyday." This holyday was the annual meeting of the militia of the state. Every reader who can recollect in the times of his boyhood how delightfully the old distich,

"First Monday in May
Is training day,"

used to sound in his ears, when he looked forward in anticipation to the glories of that jubilee, can form some idea of the thirst for knowledge which young Fitch here evinced in denying himself a participation in its pleasures. Having thus prepared the land, he

planted it with potatoes, cultivating them at noontimes and at evenings, after the labors of the day were over. He says, "I raised several bushels, and in the fall sold them, and got ten shillings in money, and went to a merchant in the neighborhood who dealt in New York, who promised me to get the book, and fulfilled his promise. But the book cost twelve shillings, and I was two shillings in debt, which gave me a great deal of uneasiness. By some means, I do not recollect how, I soon discharged it, but was obliged to return the seed to my father in the fall.

"What makes me pretty sure it happened when I was eleven years of age, is this: it was about one year after I planted the potatoes before I got the book, and I learned surveying that winter I was thirteen years of age, and when I learned that, I presume I was the best geographer of the *world*, that Connecticut could produce, according to Salmon, at that time. No question could be asked me of any nation, but I would tell their number, religion, their latitude and longitude, and turn at once to any town marked on the maps, which could not be acquired in less than in about one year, considering the small opportunities I had of studying, which was only in the intervals of hard labor and times for rest.

"My father never allowed me to go to school more than one month in a year, except that winter I was thirteen years of age, when he permitted me to go about five or six weeks. After I had got through with common arithmetic, my master told me in public school that he could learn me no farther in arithmetic, but, if I chose, he would learn me surveying. I so earnestly insisted on my father to indulge me in this, that he could not resist my entreaties, and went to Hartford and got a scale and a pair of dividers, and on his return I never felt a greater sense of gratitude to *mortal man* than I did to him at that time, and in two weeks learned what we called surveying in New England. I knew no better, but thought myself perfect master, but learned nothing of logarithms, or of calculation by latitude and departure, only geometrically. As I had learned common arithmetic out of school by myself, I had but little to do while there, only to go through what I had really learned, except division, which took me about half a day to learn the different mode before I could be ready at it."

"My father had meadow lands adjoining the governor of the colony. He frequently came under the shade with us in mowing time; and seeing me a little, forward boy, one day requested my father to let me go to carry the chain with him, to measure off some small parcels. His request was easily granted, as is common for poor men to exert themselves to oblige the great. This

happened when I was about ten or eleven years of age. In this undertaking the governor was exceedingly familiar with me, and would consult me on the most minute part of the business as much as if I had been an able counsellor, and as if he knew nothing of the business himself. I was equally proud of his company, and as officious as I could be to render him every service."

"We could not finish the surveying that evening, but left, I believe, seven or eight acres when we quit. He left the chain, and gave me directions how to lay it off for sundry people; I being proud of the office, readily accepted it, and executed it faithfully. Some time after, the governor called at my father's house for the chain; I fetched it to him with the greatest expedition, and expectation of some pennies, when he took it, put it in his saddle-bags, and rode off without saying a word! My mortification at this time was nearly equal to the usage I met with in extinguishing the fire in my father's house; yet I am persuaded the governor was an honest man, but concluded within himself that the *honor* would fully compensate me."

On leaving school, Fitch's whole time was devoted to the labors of the farm. His duties were so very severe, that he expresses an opinion that it "stunted him," and prevented his growth for several years. Independent of the severity of his father in thus keeping him so hard at work, he was subject to the tyranny of an elder brother, who sought every opportunity to oppress him and crush his spirits, cruelly compelling him to such an exertion in his labors that he was often "ready to faint," and speaking in such a manner as to put him in continual apprehension of a beating. "For this treatment," says he, "I do not thank my unfeeling father and tyrant brother; and although I have not seen him for twenty years, would not go to the nearest neighbor's to see him, unless he was in distress. Could I be set into a Virginia field amongst their slaves, with the severest driver at my back, I would sooner engage in it than go through the same again."

In speaking of an almost miraculous escape from injury in falling from a tree which happened about this period, he observes, "it seems heaven designed me for some more cruel fate."

While on the farm, young Fitch was extremely desirous to study astronomy, and in vain solicited his father to procure the necessary works; but, in some degree from the severity of his duties, partly from the want of books, and having already attained a greater amount of learning than any of his neighbors, he continues, "I imperceptibly left my studies, and fell into the common practices of boys in our neighborhood, and devoted myself to play, when I could steal a minute, as much as I had before to my books.

This helped to sweeten life; and from the time I was thirteen and fourteen years of age until I went apprentice, I enjoyed myself as well as most of the Virginia slaves, who have liberty to go to a dance once a week."

"During that time there was nothing material happened to me. I seemed to be beloved both by old and young, as I could speak rationally to the old, and was always foremost among my playfellows."

When about seventeen years of age, Fitch was anxious to learn some trade or go to sea, by which he "could make a living when he came to himself." He expressed these views to his father, at the same time representing that he was too small and weak to obtain a support by agricultural employments. His parent reluctantly consented. In the following September the steeple to the village church was raised. This was indeed a gala day, and the people from Hartford and the whole country round flocked to witness this then uncommon spectacle. Although, as he tells us, he had "a singular curiosity in witnessing mechanical operations," yet was determined to forego the pleasure, and borrowed a horse for the purpose of visiting Rocky Hill, a parish in Wethersfield, where there were a great number of coasters. The object of this visit was to engage a berth for a short voyage, to settle his opinion as to the propriety of learning a trade or becoming a seaman.

A place was first engaged on board of a sloop bound to New York, "under one Captain Abbott." This situation was found very disagreeable. The master treated him with brutality; and although there were plenty of empty berths, he was compelled by the mate Starr, to lie upon deck on a chest, much too short, and this, too, without any covering. Such usage was considered "extremely hard, after having been used to a comfortable bed at home."

An occasion offering a day or two subsequent, he left and went on board of a Providence sloop. Here things were found very comfortable, and although not in accordance to stipulation, Fitch evinced such zeal and industry that his master paid him wages, and he made a "saving voyage." "I returned home," says he, "neither enamoured with the sea nor resolved against it, and in as much of a quandary how to dispose of myself as ever."

Accident, however, soon threw him in the way of a neighboring clockmaker, who proposed to him to enter into his service. On expressing to his parents his desire to learn the business, they strenuously opposed his wishes, and this, too, without any regard to their son's welfare, but merely from a selfish unwillingness to dispense with his services on the farm, which had then become

quite valuable. Their opposition came near frustrating the plan. On mentioning his troubles to his sister and her husband, Mr. Timothy King, although poor, they offered to advance the necessary funds. Fitch says, "these two persons were the greatest ornament that ever adorned my father's family. My sister was the most mannerly, generous-spirited woman that I ever saw, not only to me, but to others, and probably might take it in some manner from her husband, as good wives endeavor to recommend themselves to their husbands by adopting their sentiments." Other obstacles were thrown in his way, but he successfully overcame them.

He describes the clockmaker as an eccentric man, and possessing some genius. According to agreement, Fitch was to work seven months in the year in the out-door concerns of his employer,—the remainder of the time to devote to the pursuit of the art and mysteries of wooden clock-making. But his master by no means acted in conformity to contract, keeping his apprentice almost continually in attendance upon his domestic concerns; and even during the small portion of the time he was employed in the shop, so neglected to instruct him, that at the expiration of two years and a half, Fitch left almost entirely ignorant of his profession.

After this he went to work with a brother of his former employer, who was engaged in a similar business, and who united with the manufacture of clocks the repairing of watches. This latter art it was especially stipulated should be taught his new apprentice; he not only omitted to do it, but took particular pains to prevent his learning, working himself in a distant part of the room, locking up his tools when absent, and forbidding Fitch ever to touch them. Fitch was always kept busy on some unimportant part, so that during the eight months he was in this person's service, he never even saw a watch taken to pieces or put together, and, in fact, had no opportunity of obtaining any insight of the subject whatever. Nor did oppression end here; "although," he observes, "I possessed a small appetite, I never was given sufficient to satisfy it, except on one occasion, when I managed to make a good, hearty meal on potatoes. Being an inferior, I was helped last at the table; the females would then discourse upon gluttony, and my master, hastily devouring his own food, would immediately return thanks for that which himself and others eat, as well as for that which his apprentice did *not*." Fitch was kept very hard and steady at work from before sunrise in winter until ten o'clock at night, and as many hours during the summer, with, however, one single exception,—this was on the occasion of the sickness and death of his master's child, when

he was obliged to walk six miles for a physician. Shortly after his return the child died. "During the night," says he, "I watched with the corpse, with the privilege of as much water from the well as I desired, by way of refreshment."

On leaving his last employer, he dared not set up the business on his own account, or work as a journeyman, for fear of exhibiting his ignorance, but employed himself, as he tells us, "in doing small brass work." This was pursued by him with so much industry, that at the end of two years he found himself worth fifty pounds, which for him, considering the scarcity of money at the time, was viewed as "quite a treasure," and enabled him to pay off his debts, and have something "handsome left." Fitch afterwards entered into the potash business, but was unsuccessful in its prosecution, arising partially from the unfaithfulness of one of his partners. While thus engaged, he married Miss Lucy Roberts, on 29th December, 1767; but owing to her unhappy temper and disposition, was compelled, in the course of a year or two, to abandon her, being thoroughly convinced that it was for the happiness of both that they should separate. This event occasioned him great affliction, from being obliged to leave a child whom he "loved as dear as himself." A misfortune subsequently happening to her, he observes, "could I have foreseen it, I should never have abandoned her, but have endeavored to worry through life in her company as well as I might."

On forsaking the place of his nativity, Fitch went to Pittsfield, Mass., but not having constant employment there, visited Albany, yet with no better success. A short time after, we find him in New Jersey, in a destitute condition, endeavoring to find employment on some farm as a common laborer, but his sickly appearance baffled all his efforts,—no one would employ him. Finally, he entered into the business of making buttons, which he pursued with tolerable success, first at New Brunswick, and afterwards at Trenton.

At the commencement of the revolution, Fitch espoused the popular cause, and during a portion of the time rendered himself very useful in repairing arms for the continental army. Subsequently he removed to Kentucky, where he received the appointment and practised as a surveyor. While at the West, and in navigating a river in a small boat, Fitch and his companions were taken prisoners and carried into captivity by the Indians, but after considerable hardship and suffering, were released. At a subsequent period he became once more an inhabitant of one of the Atlantic states.

"In the month of April, 1785," says Fitch, in the manuscript

alluded to, "I was so unfortunate as to have an idea that a carriage might be carried by the force of steam along the roads. I pursued that idea about one week, and gave it over as impracticable, or, in other words, turned my thoughts to vessels. From that time I have pursued the idea to this day with unremitted assiduity, yet do frankly confess that it has been the most imprudent scheme that ever I engaged in. The perplexities and embarrassments through which it has caused me to wade, far exceed any thing that the common course of life ever presented to my view, and to reflect on the disproportion of a man of my abilities to such a task, I am to charge myself with having been deranged; and had I not the most convincing proofs to the contrary, should most certainly suppose myself to have been *non compos mentis* at the time."

In another place he remarks, "If I had the abilities of Cicero, it would have been nothing less than madness in me to have undertaken it, in my state of penury. Had I been a nobleman of £3000, it would barely have justified my conduct."

Again, he says, "What I am now to inform you of I know will not be to my credit, but, so long as it is the truth, I will insert it, viz., that I did not know that there was a steam engine on earth when I proposed to gain a force by steam; and I leave my first drafts and descriptions behind, that you may judge whether I am sincere or not. A short time after drawing my first draft for a boat, I was amazingly chagrined to find, at Parson Irwin's, in Bucks county, a drawing of a steam engine; but it had the effect to establish me in my other principles, as my doubts lay at that time in the engine only."

The following account of Fitch's experiments is written by one of his early patrons, the late Dr. Thornton, of the patent office at Washington, and is entitled "A short account of the origin of steamboats:"—

"Finding that Mr. Robert Fulton,* whose genius and talents I highly respect, has been considered by some the inventor of the steamboat, I think it a duty to the memory of the late JOHN FITCH to set forth, with as much brevity as possible, the fallacy of this opinion; and to show, moreover, that if Mr. Fulton has any claim whatever to originality in his steamboat, it must be exceedingly limited.

"In the year 1788, the late John Fitch applied for, and obtained a patent for the application of steam to navigation, in the

* It may not be invidious here to mention, that one great advantage which Mr. Fulton possessed over many, if not all preceding experimenters, was the use of one of Watt's improved steam engines.

states of New York, Pennsylvania, New Jersey, Delaware, &c.; and soon after, the late Mr. James Rumsey,* conceiving he had made some discoveries in perfecting the same, applied to the state of Pennsylvania for a patent; but a company formed by John

* *Biographical Sketch of James Rumsey.*—"This individual was a native of Maryland, and, when a young man, removed to Shepherdstown, Virginia, where he occupied himself exclusively in mechanical subjects. As early as July or August, 1783, he directed his attention to the subject of navigation by steam; and, under the most disadvantageous circumstances, succeeded, in the autumn of 1784, in making a private, but very imperfect experiment, in order to test some of the principles of his invention. This so well convinced him of its ultimate success, that at the October session of the Virginia legislature for that year, he applied for and obtained an act, guarantying to him the exclusive use of his invention in navigating the waters of that state. About the same time also he communicated his invention to General Washington. In January, 1785, he obtained a patent from the general assembly of Maryland for navigating their waters. Through the whole of this year, Rumsey was deeply engaged in building a boat, and procuring, improving, adapting, and testing the several parts of his machinery; but, from obvious causes, was not ready for a public trial until the year following, (1786,) which, all things considered, was eminently successful. In this trial he succeeded in propelling his boat by steam alone *against the current of the Potomac, near Shepherdstown, at the rate of four or five miles an hour!*

"Rumsey's boat was about fifty feet in length, and, as observed in the text, was propelled by a pump worked by a steam engine, which forced a quantity of water up through the keel; the valve was then shut by the return of the stroke, which at the same time forced the water through a channel or pipe, a few inches square (lying above or parallel to the kelson,) out at the stern under the rudder, which had a less depth than usual, to permit the exit of the water. The impetus of this water, forced through the square channel against the exterior water, acted as an impelling power upon the vessel. The reaction of the effluent water propelled her at the rate above mentioned, when loaded with three tons in addition to the weight of her engine of about a third of a ton. The boiler was quite a curiosity, holding no more than five gallons of water, and needing only a pint at a time. The whole machinery did not occupy a space greater than that required for four barrels of flour. The fuel consumed was not more than from four to six bushels of coals in twelve hours. Rumsey's other project was to apply the power of a steam engine to long poles, which were to reach the bottom of the river, and by that means to push a boat against a rapid current.

"After the experiment above alluded to, Rumsey being under the strong conviction that skilful workmen and perfect machinery were alone wanting to the most perfect success, and sensible that such could not be procured in America, resolved to go to England. With slender means of his own, and aided, or rather *mocked*, by some timid and unsteady patronage, he there resumed with untiring energy his great undertaking. He proceeded to procure patents of the British government for steam navigation: these patents bear date in the beginning of the year 1788. Several of his inventions, in one modified form or another, are now in general use; as, for instance, the cylindrical boiler, so superior to the old tub or still boilers, in the presentation of fire surface, and capacity for holding highly rarefied steam, is described, both single and combined, in his specifications, and is identical in principle with the tub boiler which he used in his Potomac experiment.

"Difficulties and embarrassments of a pecuniary nature, and such as invariably obstruct the progress of a new invention, attended him in England. He was often compelled to abandon temporarily his main object, and turn his attention to something else, in order to raise means to resume it. He undertook with the same power, but by its more judicious application, to produce higher results in several waterworks, in all which he succeeded, realizing thereby some reputation as well as funds to apply to his favorite project.

Fitch, under his state patents, of which the author of this was one of the principal shareholders, conceiving that the patent of Fitch was not for any peculiar mode of applying the steam to navigation, but that it extended to all known modes of propelling boats and vessels, contested before the assembly of Pennsylvania, and also before the assembly of Delaware, the mode proposed by Mr. Rumsey, and contended that the mode he proposed, viz., by drawing up the water into a tube, and forcing the same water out of the stern of the vessel or boat, which was derived from Dr. Franklin's works, (the doctor being one of the company,) was a mode the company had a right to, for the plan was originally published in Latin, about fifty years before, in the works of Bernouilli the younger. Two of Fitch's company and I appeared without counsel, and pleaded our own cause in the assembly of Pennsylvania, and after a week's patient hearing against the most learned counsel of Pennsylvania, we obtained a decision in our favor, and afterwards also in Delaware. We believed and contended that our claim of propelling boats by steam included all the modes of propelling vessels and boats then known, and that the patent was for the application of steam as an agent to the propelling powers: and the decisions of the legislatures were in favor of this construction, as Mr. Rumsey's company (of which the late Messrs. Bingham, Myers, Fisher, and many other worthy gentlemen, were members,) were excluded from the right of using steamboats on any principle."

"At another time, in order to avoid a London prison, and the delay, if not the defeat of all his high hopes, he was compelled to transfer, at what he considered a ruinous sacrifice, a large interest in his inventions,—a contract which entangled and embarrassed him through life. Still, however, he struggled on, undismayed, and had constructed a boat of about one hundred tons burden, and pushed forward his machinery so near to the point of completion, as to be able to indicate a day not very distant for a public exhibition, when his sudden death occurred from apoplexy, while discussing the principle of one of his inventions before a philosophical society of London. With his life the whole project ceased,—there was no one present to administer,—no one present able to carry it out. Few would have been willing to incur the ridicule of attempting to complete it. All that he left,—his very boat and machinery,—barely sufficed to satisfy anxious and greedy creditors."

A sharp controversy at one time existed between Rumsey and Fitch, and their mutual friends, relating to the originality of their respective inventions. Without deciding upon the merits of either, both certainly claim the highest admiration for their perseverance, as well as sympathy for their misfortunes.

For the above facts, see Stuart's Anecdotes of the Steam Engine, and the speech of Mr. Rumsey of Kentucky before the house of representatives, on the occasion of offering the following resolution, afterwards unanimously passed Feb. 9, 1839:—"Resolved by the senate and house of representatives, &c. &c., That the President be and he is hereby requested to present to James Rumsey, jun., the son and only surviving child of James Rumsey, deceased, a suitable gold medal, commemorative of his father's services and high agency in giving to the world the benefits of the steamboat."

"We worked incessantly at the boat* to bring it to perfection, and under the disadvantages of never having seen a steam engine on the principles contemplated, of not having a single engineer in our company or pay,—we made engineers of common blacksmiths; and after expending many thousand dollars, the boat did not exceed three miles an hour. Finding great unwillingness in many to proceed, I proposed to the company to give up to any one, the one-half of my shares, who would, at his own expense, make a boat go at the rate of eight miles an hour, in dead water, in eighteen months, or forfeit all the expenditures on failing; or I would engage with any others to accept these terms. Each relinquished one half of his shares, by making the forty shares eighty, and holding only as many of the new shares as he held of the old ones, and then subscribed as far as he thought proper to enter on the terms: by which many relinquished one half. I was among the number, and in less than twelve months we were ready for the experiment.

"The day was appointed, and the experiment made in the following manner:—A mile was measured in Front (Water) street, Philadelphia, and the bounds projected at right angles, as exactly as could be to the wharf, where a flag was placed at each end, and also a stop watch. The boat was ordered under way at dead water, or when the tide was found to be without movement; as the boat passed one flag, it struck, and at the same instant the watches were set off; as the boat reached the other flag it was also struck, and the watches instantly stopped. Every precaution was taken before witnesses: the time was shown to all; the experiment declared to be fairly made, and the boat was found to go at the rate of *eight miles an hour*, or one mile in seven minutes

* *Description of Fitch's Steamboat.*—The following account of Mr. Fitch's boat is given by the unfortunate inventor in the Columbian (Philadelphia) Magazine, vol. i. for December, 1786, of which the engraving annexed will give some idea. "The cylinder is to be horizontal, and the steam to work with equal force at each end. The mode by which we obtain a vacuum is, it is believed, entirely new, as is also the method of letting the water into it and throwing it off against the atmosphere without any friction. It is expected that the cylinder, which is of twelve inches diameter, will move a clear force of eleven or twelve cwt. after the frictions are deducted; this force is to be directed against a wheel eighteen inches in diameter. The piston is to move about three feet, and each vibration of it gives the axis about forty evolutions. Each evolution of the axis moves twelve oars or paddles five and a half feet; they work perpendicularly, and are represented by the strokes of a paddle of a canoe. As six of the paddles are raised from the water, six more are entered, and the two sets of paddles make their strokes of about eleven feet in each evolution. The crank of the axis acts upon the paddles, about one third of their length from their lower ends, on which part of the oar the whole force of the axis is applied. The engine is placed in the bottom of the boat, about one third from the stern, and both the action and reaction turn the wheel the same way."

and a half; on which the shares were signed over with great satisfaction by the rest of the company. It afterwards went *eighty miles in a day!*

"The governor and council of Pennsylvania were so highly gratified with our labors, that without their intentions being previously known to us, Governor Mifflin, attended by the council in procession, presented to the company, and placed in the boat, a superb silk flag, prepared expressly, and containing the arms of Pennsylvania; and this flag we possessed till Mr. Fitch was sent to France by the company, at the request of Aaron Vail, Esq., our consul at L'Orient, who, being one of the company, was solicitous to have steamboats built in France. John Fitch took the flag, unknown to the company, and presented it to the national convention. Mr. Vail, finding all the workmen put in requisition, and that none could be obtained to build the boats, paid the expenses of Mr. Fitch, who returned to the United States; and Mr. Vail afterwards subjected to the examination of Mr. Fulton, when in France, the papers and designs of the steamboat appertaining to the company."

"As Dr. Thornton has stated in his account, as quoted above, the company refused to advance more funds. This they did, after *interfering* with his views, and attempting expensive plans of improvement, which failed of success; and being probably influenced by that *unceasing ridicule* cast upon the project, they one by one gradually withdrew from the concern. The conviction of Fitch, however, respecting the power of steam, continued firm; and in June, 1792, when the boat was laid up, he addressed a letter on the subject to Mr. Rittenhouse, one of the shareholders, in which he says, 'it would be much easier to carry a first-rate man-of-war by steam than a boat, as we would not be cramped for room, nor would the weight of machinery be felt. *This, sir, will be the mode of crossing the Atlantic in time*, whether I bring it to perfection or not, for packets and armed vessels. I mean to make use of the wind when we have it, and in a calm to pursue the voyage at the rate of seven or eight miles an hour.' He further suggests the use of steam to conquer the cruisers of Barbary, by which several American vessels had then been lately captured. He says, 'a six-foot cylinder could discharge a column of water from the round top forty or fifty yards, and throw a man off his feet, and wet their arms and ammunition.' He complains of his poverty; and to raise funds, he urges Mr. Rittenhouse to purchase his lands in Kentucky, that he 'might have the honor of enabling him to complete the great undertaking.'

"Fitch's enthusiasm on the subject never diminished one mo-

ment, and *steam* was the constant theme of his discourse whenever he could prevail upon any one to listen to him. Upon one occasion he called upon a smith who had worked at his boat, and after dwelling some time upon his favorite topic, concluded with these prophetic words: 'Well, gentlemen, although I shall not live to see the time, you will, when steamboats will be preferred to all other means of conveyance, and especially for passengers; and they will be particularly useful in the navigation of the river Mississippi.' He then retired, when a person present observed, in a tone of deep sympathy, '*Poor fellow! what a pity he is crazy!*' The predictions of the benefits which this country would derive from steam navigation are frequently referred to in his manuscript left to the library company."

On the return from his unsuccessful sojourn in Europe, Fitch landed at Boston in a very needy and destitute condition. A relation, Colonel George King, of Sharon, Connecticut, hearing of his friendless situation, sent for and generously offered him a home under his own roof. Here he remained two or three years, and some time in 1796 went out to Kentucky, to obtain possession of some lands which he had purchased while surveying there. For this purpose, writs of ejectment were issued against those illegally occupying them; and just as a better day was dawning upon the career of this most singularly unfortunate man, he was seized with a fever of the country, and died.

"In conformity to his wishes, he was buried on the shores of the Ohio, that he might repose '*where the song of the boatmen would enliven the stillness of his resting place, and the music of the steam engine sooth his spirit!*' What an idea!—yet how natural to the mind of an ardent projector, who had been so long devoted to one darling object, which it was not *his* destiny to accomplish!—and how touching is the sentiment found in his journal:—'The day will come when some more powerful man will get fame and riches from my invention, but nobody will believe that *poor John Fitch can do any thing worthy of attention!*'"

BENJAMIN FRANKLIN.

Birth.—Intended for the church.—Attends a common school.—Assists his father in the tallow chandlery.—Dislikes the business.—Tries the cutler's trade.—Becomes an apprentice in his brother's printing-office.—Evinces great fondness for books.—Is allowed access to a gentleman's library.—Turns poet, and hawks his productions through the streets.—Rising vanity checked.—His friend Collins, and their discussions.—Meets with an odd volume of the Spectator.—Improvement in composition.—Economy, and new system of diet.—Masters arithmetic, and studies navigation.—Secretly contributes to his brother's newspaper.—A discovery.—Is viewed as a person of some consequence.—Quarrels with his brother.—First error in life.—Privately leaves for New York.—Destitute condition.—Proceeds to Philadelphia.—Graphic description.—Enters into the printing-office of Keimer.—Makes a distinguished acquaintance.—Dines with Governor Keith.—Informs his parents of his situation.—Goes out to England under the supposed patronage of the governor.—Disappointment and imposition.—Thrown upon his own resources, and works in London as a journeyman printer.—Writes a pamphlet.—Attracts the attention of literary men.—Frugality and temperance.—Sets an example.—A friend returning to Philadelphia, is engaged as his clerk.—Voyage.—Forms a plan for future conduct.—Arrival at Philadelphia.—Death of his friend.—Once more thrown upon the world.—Enters again into Keimer's service.—Franklin and Meredith set up a printing-office.—Industry.—Rising credit.—Thinks of establishing a new paper.—Treachery.—Its defeat.—Purchases Keimer's paper.—Growing popularity.—Buys out his partner.—Opens a stationer's shop.—Marries.—Establishes the first American circulating library.—Publishes "Poor Richard's Almanac."—Studies languages.—Chosen clerk of the general assembly.—Appointed deputy postmaster.—Becomes interested in public affairs—Suggests various public improvements.—Made an alderman.—Elected burgess to the general assembly.—Interesting electrical discoveries.—Draws down lightning from the clouds.—Increasing honors.—Becomes an eminent statesman.—Signs the declaration of independence.—Sent ambassador to the court of France.—Chosen president of the supreme executive council.—Character.—Death.—Anecdotes.

The name we are now to mention is perhaps the most distinguished to be found in the annals of self-education. Of all those, at least, who, by their own efforts, and without any usurpation of the rights of others, have raised themselves to a high place in society, there is no one, as has been remarked, the close of whose history presents so great a contrast to its commencement as that of Benjamin Franklin. It fortunately happens, too, in his case, that we are in possession of abundant information as to the methods by which he contrived to surmount the many disadvantages of his original condition; to raise himself from the lowest poverty and obscurity to affluence and distinction; and, above all, in the absence of instructors, and of the ordinary helps to the acquisition

of knowledge, to enrich himself so plentifully with the treasures of literature and science, as not only to be enabled to derive from that source the chief happiness of his life, but to succeed in placing himself high among the most famous writers and philosophers of his time. We shall avail ourselves, as liberally as our limits will permit, of the ample details, respecting the early part of his life especially, that have been given to the public, in order to present to the reader as full and distinct an account as possible of the successive steps of a progress so eminently worthy of being recorded, both from the interesting nature of the story, and from its value as an example and lesson, perhaps the most instructive to be anywhere found, for all who have to be either the architects of their own fortunes, or their own guides in the pursuit of knowledge.

Franklin has himself told us the story of his early life inimitably well. The narrative is given in the form of a letter to his son; and does not appear to have been written originally with any view to publication. "From the poverty and obscurity," he says, "in which I was born, and in which I passed my earliest years, I have raised myself to a state of affluence, and some degree of celebrity in the world. As constant good fortune has accompanied me, even to an advanced period of life, my posterity will perhaps be desirous of learning the means which I employed, and which, thanks to Providence, so well succeeded with me. They may also deem them fit to be imitated, should any of them find themselves in similar circumstances." It is not many years since this letter was, for the first time, given to the world by the grandson of the illustrious writer, only a small portion of it having previously appeared, and that merely a re-translation into English from a French version of the original manuscript which had been published at Paris.

Franklin was born at Boston, on the 17th of January, 1706; the youngest, with the exception of two daughters, of a family of seventeen children. His father, who had emigrated from England about twenty-four years before, followed the occupation of a soap-boiler and tallow-chandler, a business to which he had not been bred, and by which he seems with difficulty to have been able to support his numerous family. At first it was proposed to make Benjamin a clergyman; and he was accordingly, having before learned to read, put to the grammar-school at eight years of age; —an uncle, whose namesake he was, and who appears to have been an ingenious man, encouraging the project by offering to give him several volumes of sermons to set up with, which he had taken down, in a short-hand of his own invention, from the different preachers he had been in the habit of hearing. This person, who

was now advanced in life, had been only a common silk-dyer, but had been both a great reader and writer in his day, having filled two quarto volumes with his own manuscript poetry. What he was most proud of, however, was his short-hand, which he was very anxious that his nephew should learn. But young Franklin had not been quite a year at the grammar-school, when his father began to reflect that the expense of a college education for him was what he could not very well afford. He was removed, and placed for another year under a teacher of writing and arithmetic; after which his father took him home, when he was no more than ten years old, to assist him in his own business. Accordingly he was employed, he tells us, in cutting wicks for the candles, filling the moulds for cast candles, attending the shop, going errands, and other drudgery of the same kind. He showed so much dislike, however, to this business, that his father, afraid he would break loose and go to sea, as one of his elder brothers had done, found it advisable, after a trial of two years, to look about for another occupation for him; and taking him round to see a great many different sorts of tradesmen at their work, it was at last agreed upon that he should be bound apprentice to a cousin of his own, who was a cutler. But he had been only for some days on trial at this business, when, his father thinking the apprentice-fee which his cousin asked too high, he was again taken home. In this state of things it was finally resolved to place him with his brother James, who had been bred a printer, and had just returned from England and set up on his own account at Boston. To him, therefore, Benjamin was bound apprentice, when he was yet only in his twelfth year, on an agreement that he should remain with him in that capacity till he reached the age of twenty-one.

One of the principal reasons which induced his father to determine upon this profession for him, was the fondness he had from his infancy shown for reading. All the money he could get hold of used to be eagerly laid out in the purchase of books. His father's small collection consisted principally of works in controversial divinity, a subject of little interest to a reader of his age; but, such as they were, he went through most of them. Fortunately there was also a copy of Plutarch's Lives, which he says he read abundantly. This, and a book by Daniel Defoe, called an Essay on Projects, he seems to think were the two works from which he derived the most advantage. His new profession of a printer, by procuring him the acquaintance of some booksellers' apprentices, enabled him considerably to extend his acquaintance with books, by frequently borrowing a volume in the evening, which he sat up reading the greater part of the night, in order that he might return

it in the morning, lest it should be missed. But these solitary studies did not prevent him from soon acquiring a great proficiency in his business, in which he was every day becoming more useful to his brother. After some time, too, his access to books was greatly facilitated by the kindness of a liberal-minded merchant who was in the habit of frequenting the printing-office, and, being possessed of a tolerable library, invited young Franklin, whose industry and intelligence had attracted his attention, to come to see it; after which he allowed him to borrow from it such volumes as he wished to read.

Our young student was now to distinguish himself in a new character. The perusal of the works of others suggested to him the idea of trying his own talent at composition; and his first attempts in this way were a few pieces of poetry. Verse, it may be observed, is generally the earliest sort of composition attempted either by nations or individuals, and for the same reasons in both cases—namely, first, because poetry has peculiar charms for the unripe understanding; and, secondly, because people at first find it difficult to conceive what composition is at all, independently of such measured cadences and other regularities as constitute verse. Franklin's poetical fit, however, did not last long. Having been induced by his brother to write two ballads, he was sent to sell them through the streets; and one of them, at least, being on a subject which had just made a good deal of noise in the place, sold, as he tells us, prodigiously. But his father, who, without much literary knowledge, was a man of a remarkably sound and vigorous understanding, soon brought down the rising vanity of the young poet, by pointing out to him the many faults of his performances, and convincing him what wretched stuff they really were. Having been told, too, that verse-makers were generally beggars, with his characteristic prudence he determined to write no more ballads.

He had an intimate acquaintance of the name of Collins, who was, like himself, passionately fond of books, and with whom he was in the habit of arguing upon such subjects as they met with in the course of their reading. Among other questions which they discussed in this way, one accidentally arose on the abilities of women, and the propriety of giving them a learned education. Collins maintained their natural unfitness for any of the severer studies, while Franklin took the contrary side of the question—"perhaps," he says, "a little for dispute sake." His antagonist had always the greater plenty of words; but Franklin thought that, on this occasion in particular, his own arguments were rather the stronger; and on their parting without settling the point, he sat down, and put a summary of what he advanced in writing, which

he copied out and sent to Collins. This gave a new form to the discussion, which was now carried on for some time by letters, of which three or four had been written on both sides, when the correspondence fell into the hands of Franklin's father. His natural acuteness and good sense enabled him here again to render an essential service to his son, by pointing out to him how far he fell short of his antagonist in elegance of expression, in method, and in perspicuity, though he had the advantage of him in correct spelling and punctuation, which he evidently owed to his experience in the printing-office. From that moment Franklin determined to spare no pains in endeavoring to improve his style; and we shall give, in his own words, the method he pursued for that end.

"About this time," says he, "I met with an odd volume of the Spectator; I had never before seen any of them. I bought it, read it over and over, and was much delighted with it. I thought the writing excellent; and wished, if possible, to imitate it. With that view, I took some of the papers, and making short hints of the sentiments in each sentence, laid them by a few days; and then, without looking at the book, tried to complete the papers again, by expressing each hinted sentiment at length, and as fully as it had been expressed before, in any suitable words that should occur to me. Then I compared my Spectator with the original, discovered some of my faults, and corrected them. But I found I wanted a stock of words, or a readiness in recollecting and using them, which I thought I should have acquired before that time if I had gone on making verses; since the continual search for words of the same import, but of different length, to suit the measure, or of different sound for the rhyme, would have laid me under a constant necessity of searching for variety, and also have tended to fix that variety in my mind, and make me master of it. Therefore, I took some of the tales in the Spectator, and turned them into verse; and after a time, when I had pretty well forgotten the prose, turned them back again. I also sometimes jumbled my collection of hints into confusion; and, after some weeks, endeavored to reduce them into the best order, before I began to form the full sentences and complete the subject. This was to teach me method in the arrangement of the thoughts. By comparing my work with the original, I discovered many faults, and corrected them; but I sometimes had the pleasure to fancy that in certain particulars of small consequence I had been fortunate enough to improve the method or the language; and this encouraged me to think that I might, in time, come to be a tolerable English writer, of which I was extremely ambitious."

Even at this early age nothing could exceed the perseverance and self-denial which he displayed, in pursuing his favorite object of cultivating his mental faculties to the utmost of his power. When only sixteen, he chanced to meet with a book in recommendation of a vegetable diet, one of the arguments at least in favor of which made an immediate impression upon him—namely : its greater cheapness ; and from this and other considerations, he determined to adopt that way of living for the future. Having taken this resolution, he proposed to his brother, if he would give him weekly only half what his board had hitherto cost, to board himself, an offer which was immediately accepted. He presently found that by adhering to his new system of diet he could still save half what his brother allowed him. "This," says he, "was an additional fund for buying of books : but I had another advantage in it. My brother and the rest going from the printing-house to their meals, I remained there alone, and despatching presently my light repast, (which was often no more than a biscuit, or a slice of bread, a handful of raisins, or a tart from the pastrycook's, and a glass of water,) had the rest of the time, till their return, for study ; in which I made the greater progress, from that greater clearness of head and quicker apprehension which generally attend temperance in eating and drinking." It was about this time that, by means of Cocker's Arithmetic, he made himself master of that science, which he had twice attempted in vain to learn while at school ; and that he also obtained some acquaintance with the elements of geometry, by the perusal of a Treatise on Navigation. He mentions, likewise, among the works which he now read, Locke on the Human Understanding, and the Port-Royal Art of Thinking, together with two little sketches on the arts of Logic and Rhetoric, which he found at the end of an English Grammar, and which initiated him in the Socratic mode of disputation, or that way of arguing by which an antagonist, by being questioned, is imperceptibly drawn into admissions which are afterwards dexterously turned against him. Of this method of reasoning he became, he tells us, excessively fond, finding it very safe for himself and very embarrassing for those against whom he used it ; but he afterwards abandoned it, apparently from a feeling that it gave advantages rather to cunning than to truth, and was better adapted to gain victories in conversation, than either to convince or to inform.

A few years before this his brother had begun to publish a newspaper, the second that had appeared in America. This brought most of the literary people of Boston occasionally to the printing-office ; and young Franklin often heard them conversing

about the articles that appeared in the newspaper, and the approbation which particular ones received. At last, inflamed with the ambition of sharing in this sort of fame, he resolved to try how a communication of his own would succeed. Having written his paper, therefore, in a disguised hand, he put it at night under the door of the printing-office, where it was found in the morning, and submitted to the consideration of the critics, when they met as usual. "They read it," says he; "commented on it in my hearing; and I had the exquisite pleasure of finding it met with their approbation; and that in their different guesses at the author, none were named but men of some character among us for learning and ingenuity." "I suppose," he adds, "that I was rather lucky in my judges, and that they were not really so very good as I then believed them to be." Encouraged, however, by the success of this attempt, he sent several other pieces to the press in the same way, keeping his secret, till, as he expresses it, all his fund of sense for such performances was exhausted. He then discovered himself, and immediately found that he began to be looked upon as a person of some consequence by his brother's literary acquaintances.

This newspaper soon after afforded him, very unexpectedly, an opportunity of extricating himself from his indenture to his brother, who had all along treated him with great harshness, and to whom his rising literary reputation only made him more an object of envy and dislike. An article which they had admitted having offended the local government, his brother, as proprietor of the paper, was not only sentenced to a month's imprisonment, but prohibited from any longer continuing to print the offensive journal. In these circumstances, it was determined that it should appear for the future in the name of Benjamin, who had managed it during his brother's confinement; and in order to prevent it being alleged that the former proprietor was only screening himself behind one of his apprentices, the indenture by which the latter was bound was given up to him; he at the same time, in order to secure to his brother the benefit of his services, signing new indentures for the remainder of his time, which were to be kept private. "A very flimsy scheme it was," says Franklin; "however, it was immediately executed; and the paper was printed accordingly under my name for several months. At length a fresh difference arising between my brother and me, I took upon me to assert my freedom, presuming that he would not venture to produce the new indenture. It was not fair in me to take this advantage; and this I therefore reckon one of the first *errata* of my life; but the unfairness of it weighed little with me, when under the impressions of resentment

for the blows his passion too often urged him to bestow upon me, though he was otherwise not an ill-natured man: perhaps I was too saucy and provoking."

Finding, however, that his brother, in consequence of this exploit, had taken care to give him such a character to all those of his own profession in Boston, that nobody would employ him there, he now resolved to make his way to New York, the nearest place where there was a printer; and accordingly, after selling his books to raise a little money, he embarked on board a vessel for that city, without communicating his intention to his friends, who he knew would oppose it. In three days he found himself at the end of his voyage, near three hundred miles from his home, at the age of seventeen, without the least recommendation, as he tells us, or knowledge of any person in the place, and with very little money in his pocket. Worst of all, upon applying to the only printer likely to give him any employment, he found that this person had nothing for him to do, and that the only way in which he could serve him was by recommending him to proceed to Philadelphia, a hundred miles farther, where he had a son, who, he believed, might employ him. We are unable, however, to follow our runaway through all the incidents of this journey, some of which were disastrous enough; but we cannot refrain from relating the following anecdote:—Being troubled, wherever he stopped, by the inquisitiveness and curiosity of the people, he was induced to try an expedient for silencing similar inquiries. Accordingly, at the next place, as soon as supper was laid, he called his landlord, when the following dialogue took place between them. "Pray, are you married?" "Yes." "What family have you got?" "Two sons and three daughters." "How many servants?" "Two, and an hostler." "Have you any objection to my seeing them?" "None, I guess." "Then be so good as to desire them all to step here." This was done; and the whole being assembled, Franklin thus addressed them: "*Good people, my name is Benjamin Franklin—I am by trade a printer—I came from Boston, and am going to Philadelphia to seek employment—I am in rather humble circumstances, and quite indifferent to news of any kind unconnected with printing. This is all I know of myself, and all I can possibly inform you; and now, I hope you will allow me to take my supper in quiet.*"

The following is Franklin's most graphic description of his first appearance in Philadelphia. After concluding the account of his voyage, "I have been the more particular," says he, "in this description of my journey, and shall be so of my first entry into that city, that you may, in your mind, compare such unlikely beginnings

with the figure I have since made there. I was in my working dress, my best clothes coming round by sea. I was dirty, from my being so long in the boat; my pockets were stuffed out with shirts and stockings; and I knew no one, nor where to look for lodging. Fatigued with walking, rowing, and the want of sleep, I was very hungry; and my whole stock of cash consisted in a single dollar, and about a shilling in copper coin, which I gave to the boatmen for my passage. At first they refused it, on account of my having rowed; but I insisted on their taking it. Man is sometimes more generous when he has little money than when he has plenty; perhaps to prevent his being thought to have but little. I walked towards the top of the street, gazing about till near Market-street, where I met a boy with bread. I had often made a meal of dry bread, and inquiring where he had bought it, I went immediately to the baker's he directed me to. I asked for biscuits, meaning such as we had at Boston; that sort, it seems, was not made in Philadelphia. I then asked for a threepenny loaf, and was told they had none. Not knowing the different prices, nor the names of the different sorts of bread, I told him to give me three-penny worth of any sort. He gave me, accordingly, three great puffy rolls. I was surprised at the quantity, but took it; and having no room in my pockets, walked off with a roll under each arm, and eating the other. Thus I went up Market-street, as far as Fourth-street, passing by the door of Mr. Read, my future wife's father, when she, standing at the door, saw me, and thought I made, as I certainly did, a most awkward, ridiculous appearance. Then I turned and went down Chesnut-street and part of Walnut-street, eating my roll all the way, and coming round, found myself again at Market-street wharf, near the boat I came in, to which I went for a draught of the river water; and being filled with one of my rolls, gave the other two to a woman and her child that came down the river in the boat with us, and were waiting to go farther. Thus refreshed, I walked again up the street, which by this time had many clean dressed people in it, who were all walking the same way. I joined them, and thereby was led into the great meeting-house of the Quakers, near the market. I sat down among them; and after looking round a while, and hearing nothing said, being very drowsy, through labor and want of rest the preceding night, I fell fast asleep, and continued so till the meeting broke up, when some one was kind enough to rouse me. This, therefore, was the first house I was in, or slept in, in Philadelphia."

Refreshed by his brief sojourn in this cheap place of repose, he then set out in quest of a lodging for the night. Next morning

he found the person to whom he had been directed, who was not, however, able to give him any employment; but upon applying to another printer in the place, of the name of Keimer, he was a little more fortunate, being set by him, in the first instance, to put an old press to rights, and afterwards taken into regular work. He had been some months at Philadelphia, his relations in Boston knowing nothing of what had become of him, when a brother-in-law, who was the master of a trading sloop, happening to hear of him in one of his voyages, wrote to him in very earnest terms to entreat him to return home. The letter which he sent in reply to this application reaching his brother-in-law when he chanced to be in company with Sir William Keith, the governor of the province, it was shown to that gentleman, who expressed considerable surprise on being told the age of the writer; and immediately said that he appeared to be a young man of promising parts, and that if he would set up on his own account in Philadelphia, where the printers were wretched ones, he had no doubt he would succeed; for his part he would procure him the public business, and do him every service in his power. Some time after this, Franklin, who knew nothing of what had taken place, was one day at work along with his master near the window, when "we saw," says he, "the governor and another gentleman, (who proved to be Colonel French, of Newcastle, in the province of Delaware,) finely dressed, come directly across the street to our house, and heard them at the door. Keimer ran down immediately, thinking it a visit to him: but the governor inquired for me, came up, and with a condescension and politeness I had been quite unused to, made me many compliments, desired to be acquainted with me, blamed me kindly for not having made myself known to him when I first came to the place, and would have me away with him to the tavern, where he was going with Colonel French, to taste, as he said, some excellent Madeira. I was not a little surprised, and Keimer stared with astonishment."

The reader already perceives that Sir William must have been rather an odd sort of person; and this becomes still more apparent in the sequel of the story. Having got his young protege to the tavern, he proposed to him, over their wine, that he should, as soon as possible, set up in Philadelphia as a master printer, only continuing to work with Keimer till an opportunity should offer of a passage to Boston, when he would return home, to arrange the matter with his father, who, the governor had no doubt, would, upon a letter from him, at once advance his son the necessary funds for commencing business. Accordingly, Franklin set out for Boston by the first vessel that sailed; and, upon his arrival,

was very kindly received by all his family, except his brother, and surprised his father not a little by presenting him with the governor's letter. For some time his father said little or nothing on the subject, merely remarking, that Sir William must be a person of small discretion, to think of setting a youth up in business who wanted three years to arrive at man's estate. But at last he decidedly refused to have any thing to do with the arrangement; and Franklin returned to his patron to tell him of his bad success, going this time, however, with the consent and blessing of his parents, who finding how industrious he had been while in Philadelphia, were willing that he should continue there. When Franklin presented himself to Sir William with his father's answer to the letter he had been honored with from that functionary, the governor observed that he was too prudent: "but since he will not set you up," added he, "I will do it myself." It was finally agreed that Franklin should proceed in person to England, to purchase types and other necessary articles, for which the governor was to give him letters of credit to the extent of one hundred pounds.

After repeated applications to the governor for the promised letters of credit, Franklin was at last sent on board the vessel for England, which was just on the point of sailing, with an assurance that Colonel French should be sent to him with the letters immediately. That gentleman soon after made his appearance, bearing a packet of despatches from the governor: in this packet Franklin was informed his letters were. Accordingly, when they got into the Britsh channel, the captain having allowed him to search for them among the others, he found several addressed to his care, which he concluded of course to be those he had been promised. Upon presenting one of them, however, to a stationer to whom it was directed, the man having opened it, merely said, "Oh, this is from Riddlesdon (an attorney in Philadelphia, whom Franklin knew to be a thorough knave;) I have lately found him to be a complete rascal;" and giving back the letter, turned on his heel, and proceeded to serve his customers. Upon this, Franklin's confidence in his patron began to be a little shaken; and, after reviewing the whole affair in his own mind, he resolved to lay it before a very intelligent mercantile gentleman, who had come over from America with them, and with whom he had contracted an intimacy on the passage. This friend very soon put an end to his doubts. "He let me," says Franklin, "into Keith's character; told me there was not the least probability that he had written any letters for me; that no one who knew him had the smallest dependence on him; and he laughed at the idea of the governor's giving me a letter of credit, having, as he said, no credit to give."

Thus thrown once more on his own means, our young adventurer found there was no resource for him but to endeavor to procure some employment at his trade in London. Accordingly, having applied to a Mr. Palmer, a printer of eminence in Bartholomew-close, his services were accepted, and he remained there for nearly a year. During this time, although he was led into a good deal of idleness by the example of a friend, somewhat older than himself, he by no means forgot his old habits of reading and study. Having been employed in printing a second edition of Wollaston's Religion of Nature, his perusal of the work induced him to compose and publish a small pamphlet in refutation of some of the author's positions, which, he tells us, he did not afterwards look back upon as altogether a wise proceeding. He employed the greater part of his leisure more profitably in reading a great many works, which (circulating libraries, he remarks, not being then in use) he borrowed, on certain terms that were agreed upon between them, from a bookseller whose shop was next door to his lodgings in Little Britain, and who had an immense collection of second-hand books. His pamphlet, however, was the means of making him known to a few of the literary characters then in London, among the rest to the noted Dr. Mandeville, author of the Fable of the Bees; and to Dr. Pemberton, Sir Isaac Newton's friend, who promised to give him an opportunity, some time or other, of seeing that great man: but this, he says, never happened. He also became acquainted about the same time with the famous collector and naturalist, Sir Hans Sloane, the Founder of the British Museum, who had heard of some curiosities which Franklin had brought over from America; among these was a purse made of *asbestos*, which he purchased from him.

While with Mr. Palmer, and afterwards with Mr. Watts, near Lincoln's Inn Fields, he gave very striking evidence of those habits of temperance, self-command, industry, and frugality, which distinguished him through after life, and were undoubtedly the source of much of the success that attended his persevering efforts to raise himself from the humble condition in which he passed his earlier years. While Mr. Watts's other workmen spent a great part of every week's wages on beer, he drank only water, and found himself a good deal stronger, as well as much more clear headed, on his light beverage, than they on their strong potations. "From my example," says he, "a great many of them left off their muddling breakfast of beer, bread, and cheese, finding they could with me be supplied from a neighboring house with a large porringer of hot water-gruel, sprinkled with pepper, crumbled with bread, and and a bit of butter in it, for the price of a pint of beer, viz,—three

half-pence. This was a more comfortable, as well as a cheaper breakfast, and kept their heads clearer. Those who continued sotting with their beer all day, were often, by not paying, out of credit at the alehouse, and used to make interest with me to get beer,—*their light*, as they phrased it, *being out*. I watched the pay-table on Saturday night, and collected what I stood engaged for them, having to pay sometimes near thirty shillings a week on their accounts. This, and my being esteemed a pretty good *riggite*, that is, a jocular verbal satirist, supported my consequence in the society. My constant attendance (I never making a *St. Monday*) recommended me to the master; and my uncommon quickness at composing occasioned my being put upon works of despatch, which are generally better paid; so I went on now very agreeably."

He spent about eighteen months altogether in London, during most part of which time he worked hard, he says, at his business. and spent but little upon himself except in seeing plays, and in books. At last his friend Mr. Denham, the gentleman with whom, as we mentioned before, he had got acquainted on his voyage to England, informed him he was going to return to Philadelphia to open a store, or mercantile establishment, there, and offered him the situation of his clerk at a salary of fifty pounds. The money was less than he was now making as a compositor; but he longed to see his native country again, and accepted the proposal. Accordingly they set sail together; and, after a long voyage, arrived in Philadelphia on the 11th of October, 1726. Franklin was at this time only in his twenty-first year; and he mentions having formed, and committed to writing, while at sea, a plan for regulating the future conduct of his life. This unfortunately has been lost; but he tells us himself, that although conceived and determined upon when he was so young, it had yet "been pretty faithfully adhered to quite through to old age."

Mr. Denham had only begun business for a few months when he died; and Franklin was once more left upon the world. He now engaged again with his old master, Keimer, the printer, who had got a better house, and plenty of new types, though he was still as ignorant of his business as he was at the time of Franklin's former connection with him. While in this situation Franklin got acquainted with several persons, like himself, fond of literary pursuits; and as the men never worked on Saturday, that being Keimer's self-appointed Sabbath, he had the whole day for reading.*

* Keimer had peculiar notions upon religious observances, and amongst other things, fancied it a Christian duty to observe the Sabbath on the last day of the week

He also showed his ingenuity, and the fertility of his resources, on various occasions. They wanted some new types, which, there being no letter-foundry in America, were only to be procured from England; but Franklin, having seen types cast in London, though he had paid no particular attention to the process, contrived a mould, made use of the letters they had as punches, struck the matrices in lead, and thus supplied, as he tells us, in a pretty tolerable way, all deficiencies. "I also," he adds, "engraved several things, on occasion; made the ink; I was warehouseman; and, in short, quite a *factotum*."

He did not, however, remain long with Keimer, who had engaged him only that he might have his other workmen taught through his means; and, accordingly, when this object was in some sort attained, contrived to pick a quarrel with him, which produced an immediate separation. He then entered into an agreement with one of his fellow-workmen, of the name of Meredith, whose friends were possessed of money, to begin business in Philadelphia in company with him, the understanding being that Franklin's skill should be placed against the capital to be supplied by Meredith. While he and his friend, however, were secretly preparing to put their plan in execution, he was induced to return for a few months to Keimer, on his earnest invitation, to enable him to perform a contract for the printing of some paper money for the State of New Jersey, which required a variety of cuts and types that nobody else in the place could supply; and the two having gone together to Burlington to superintend this business, Franklin was fortunate enough, during the three months he remained in that city, to acquire, by his agreeable manners and intelligent conversation, the friendship of several of the principal inhabitants, with whom his employment brought him into connection. Among these he mentions particularly Isaac Decow, the surveyor-general. "He was," says Franklin, "a shrewd, sagacious, old man, who told me that he began for himself, when young, by wheeling clay for the brickmakers, learned to write after he was of age, carried the chain for surveyors, who taught him surveying, and he had now by his industry acquired a good estate; and, said he, I foresee that you will soon work this man (Keimer) out of his business, and make a fortune in it at Philadelphia. He had then not the least intimation of my intention to set up there or any where."

Soon after he returned to Philadelphia, the types that had been sent for from London arrived; and, settling with Keimer, he and his partner took a house, and commenced business. "We had scarce opened our letters," says he, "and put our press in order, before George House, an acquaintance of mine, brought a coun

tryman to us, whom he had met in the street, inquiring for a printer. All our cash was now expended in the variety of particulars we had been obliged to procure, and this countryman's five shillings, being our first-fruits, and coming so seasonably, gave me more pleasure than any crown I have since earned; and, from the gratitude I felt towards House, has made me often more ready than perhaps I otherwise should have been, to assist young beginners." He had, in the autumn of the preceding year, suggested to a number of his acquaintances a scheme for forming themselves into a club for mutual improvement; and they had accordingly been in the habit of meeting every Friday evening, under the name of the Junto. All the members of this association exerted themselves in procuring business for him; and one of them, named Breinthal, obtained from the Quakers the printing of forty sheets of a history of that sect of religionists, then preparing at the expense of the body. "Upon these," says Franklin, "we worked exceeding hard, for the price was low. It was a folio. I composed a sheet a day, and Meredith worked it off at press. It was often eleven at night, and sometimes later, before I had finished my distribution for the next day's work: for the little jobs sent in by our other friends, now and then, put us back. But so determined was I to continue doing a sheet a day of the folio, that one night, when, having imposed my forms, I thought my day's work over, one of them by accident was broken, and two pages (the half of the day's work) reduced to *pi*, I immediately distributed and composed it over again before I went to bed; and this industry, visible to our neighbors, began to give us character and credit." The consequence was that business, and even offers of credit, came to them from all hands.

They soon found themselves in a condition to think of establishing a newspaper; but Franklin having inadvertently mentioned this scheme to a person who came to him wanting employment, that individual carried the secret to their old master, Keimer, with whom he, as well as themselves, had formerly worked; and he immediately determined to anticipate them by issuing proposals for a paper of his own. The manner in which Franklin met and defeated this treachery is exceedingly characteristic. There was another paper published in the place, which had been in existence for some years; but it was altogether a wretched affair, and owed what success it had merely to the absence of all competition. For this print, however, Franklin, not being able to commence his own paper immediately, in conjunction with a friend, set about writing a series of amusing communications under the title of the Busy Body, which the publisher printed, of course, very gladly. "By

this means," says he, "the attention of the public was fixed on that paper; and Keimer's proposals, which we burlesqued and ridiculed, were disregarded. He began his paper, however; and before carrying it on three-quarters of a year, with at most only ninety subscribers, he offered it me for a trifle; and I, having been ready some time to go on with it, took it in hand directly, and it proved in a few years extremely profitable to me." The paper, indeed, had no sooner got into Franklin's hands than its success equalled his most sanguine expectations. Some observations which he wrote and printed in it on a colonial subject, then much talked of, excited so much attention among the leading people of the place, that it obtained the proprietors many friends in the house of assembly, and they were, on the first opportunity, appointed printers to the house. Fortunately, too, certain events occurred about this time which ended in the dissolution of Franklin's connection with Meredith, who was an idle, drunken fellow, and had all along been a mere encumbrance upon the concern. His father failing to advance the capital which had been agreed upon, when payment was demanded at the usual time by their paper merchant and other creditors, he proposed to Franklin to relinquish the partnership, and leave the whole in his hands, if the latter would take upon him the debts of the company, return to his father what he had advanced on their commencing business, pay his little personal debts, and give him thirty pounds and a new saddle. By the kindness of two friends, who, unknown to each other, came forward unasked to tender their assistance, Franklin was enabled to accept of this proposal; and thus, about the year 1729, when he was yet only in the twenty-fourth year of his age, he found himself, after all his disappointments and vicissitudes, with nothing, indeed, to depend upon but his own skill and industry for gaining a livelihood, and for extricating himself from debt, but yet in one sense fairly established in life, and with at least a prospect of well-doing before him.

Having followed his course thus far with so minute an observance of the several steps by which he arrived at the point to which we have now brought him, we shall not attempt to pursue the remainder of his career with the same particularity. His subsequent efforts in the pursuit of fortune and independence were, as is well known, eminently successful; and we find in his whole history, even to its close, a display of the same spirit of intelligence and love of knowledge, and the same active, self-denying, and intrepid virtues, which so greatly distinguished its commencement. The publication of a pamphlet, soon after Meredith had left him, in recommendation of a paper currency, a subject then

much debated in the province, obtained him such popularity, that he was employed by the government in printing the notes after they had resolved upon issuing them. Other profitable business of the same kind succeeded. He then opened a stationer's shop, began gradually to pay off his debts, and soon after married. By this time his old rival, Keimer, had gone to ruin; and he was (with the exception of an old man, who was rich, and did not care about business,) the only printer in the place. We now find him taking a leading part as a citizen. He established a circulating library, the first ever known in America, which, although it commenced with only fifty subscribers, became in course of time a large and valuable collection, the proprietors of which were eventually incorporated by royal charter. While yet in its infancy, however, it afforded its founder facilities of improvement of which he did not fail to avail himself, setting apart, as he tells us, an hour or two every day for study, which was the only amusement he allowed himself. In 1732 he first published his celebrated Almanac, under the name of *Richard Saunders*, but which was commonly known by the name of Poor Richard's Almanac. He continued this publication annually for twenty-five years. The proverbs and pithy sentences scattered up and down in the different numbers of it, were afterwards thrown together into a connected discourse under the title of the Way to Wealth, a production which has become so extensively popular, that every one of our readers is probably familiar with it.

We shall quote, in his own words, the account he gives us of the manner in which he pursued one branch of his studies:—

"I had begun," says he, "in 1733, to study languages. I soon made myself so much a master of the French, as to be able to read the books in that language with ease. I then undertook the Italian. An acquaintance, who was also learning it, used often to tempt me to play chess with him. Finding this took up too much of the time I had to spare for study, I at length refused to play any more, unless on this condition, that the victor in every game should have a right to impose a task, either of parts of the grammar to be got by heart, or in translations, &c., which tasks the vanquished was to perform upon honor before our next meeting. As we played pretty equally, we thus beat one another into that language. I afterwards, with a little pains-taking, acquired as much of the Spanish as to read their books also. I have already mentioned that I had had only one year's instruction in a Latin school, and that when very young, after which I neglected that language entirely. But when I had attained an acquaintance with the French, Italian, and Spanish, I was surprised to find, on

looking over a Latin Testament, that I understood more of that language than I had imagined, which encouraged me to apply myself again to the study of it; and I met with the more success, as those preceding languages had greatly smoothed my way."

In 1736 he was chosen clerk of the general assembly, and being soon after appointed deputy postmaster for the state, he turned his thoughts to public affairs, beginning, however, as he says, with small matters. He first occupied himself in improving the city watch; then suggested and promoted the establishment of a fire-insurance company; and afterwards exerted himself in organizing a philosophical society, an academy for the education of youth, and a militia for the defence of the province. In short, every part of the civil government, as he tells us, and almost at the same time, imposed some duty upon him. "The governor," he says, "put me into the commission of the peace; the corporation of the city chose me one of the common council, and soon after alderman; and the citizens at large elected me a burgess to represent them in assembly. This latter station was the more agreable to me, as I grew at length tired with sitting there to hear the debates, in which, as clerk, I could take no part, and which were often so uninteresting that I was induced to amuse myself with making magic squares or circles, or any thing to avoid weariness; and I conceived my becoming a member would enlarge my power of doing good. I would not, however, insinuate that my ambition was not flattered by all these promotions,—it certainly was: for, considering my low beginning, they were great things to me; and they were still more pleasing as being so many spontaneous testimonies of the public good opinion, and by me entirely unsolicited."

It is time, however, that we should introduce this extraordinary man to our readers in a new character. A much more important part in civil affairs than any he had yet acted was in reserve for him. He lived to attract to himself on the theatre of politics, the eyes, not of his own countrymen only, but of the whole civilized world; and to be a principal agent in the production of events as mighty in themselves, and as pregnant with mighty consequences, as any belonging to modern history. But our immediate object is to exhibit a portrait of the diligent student, and of the acute and patient philosopher. We have now to speak of Franklin's famous electrical discoveries. Of these discoveries we cannot, of course, here attempt to give any thing more than a very general account. But we shall endeavor to make our statement as intelligible as possible, even to those to whom the subject is new.

The term electricity is derived from *electron*, the Greek name for amber, which was known, even in ancient times, to be capable

of acquiring, by being rubbed, the curious property of attracting very light bodies, such as small bits of paper, when brought near to them. This virtue was thought to be peculiar to the substance in question, and one or two others, down to the close of the sixteenth century, when William Gilbert, a physician of London, announced for the first time, in his Latin treatise on the magnet, that it belonged equally to the diamond and many other precious stones; to glass, sulphur, sealing wax, rosin, and a variety of other substances. It is from this period that we are to date the birth of the science of Electricity, which, however, continued in its infancy for above a century, and could hardly, indeed, be said to consist of any thing more than a collection of unsystematized and ill-understood facts, until it attracted the attention of Franklin.

Among the facts, however, that had been discovered in this interval, the following were the most important. In the first place, the list of the substances capable of being excited by friction to a manifestation of electric virtue, was considerably extended. It was also found that the bodies which had been attracted by the excited substance were immediately after as forcibly repelled by it, and could not be again attracted until they had touched a third body. Other phenomena, too, besides those of attraction and repulsion, were found to take place when the body excited was one of sufficient magnitude. If any other body, not capable of being excited, such as the human hand or a rod of metal, was presented to it, a *slight sound* would be produced, which, if the experiment was performed in a dark room, would be accompanied with a momentary light. Lastly, it was discovered that the electric virtue might be imparted to bodies not capable of being themselves excited, by making such a body, when insulated, that is to say, separated from all other bodies of the same class by the intervention of one capable of excitation, act either as the rubber of the excited body, or as the drawer of a succession of sparks from it, in the manner that has just been described. It was said, in either of these cases, to be *electrified;* and it was found that if it was touched, or even closely approached, when in this state, by any other body, in like manner incapable of being excited by friction, a pretty loud report would take place, accompanied, if either body were susceptible of feeling, with a slight sensation of pain at the point of contact, and which would instantly restore the electrified body to its usual and natural condition.

In consequence of its thus appearing that all those bodies, and only those, which could not be themselves excited, might in this manner have electricity, as it were, transferred to them, they were designated *conductors*, as well as *non-electrics:* while all *electrics*,

on the other hand, were also called *non-conductors*. It is proper, however, that the reader should be aware, that of the various substances in nature, none, strictly speaking, belong exclusively to either of these classes; the truth being merely, that different bodies admit the passage of the electric influence with extremely different degrees of facility, and that those which transmit it readily are called conductors,—the metals, and fluids, and living animals particularly belonging to this class; while such as resist its passage, or permit it only with extreme reluctance,—among which are amber, sulphur, wax, glass, and silk, are described by the opposite denomination.

The beginning of the year 1746 is memorable in the annals of electricity for the accidental discovery of the possibility of accumulating large quantities of the electric fluid, by means of what was called the Leyden jar, or phial. M. Cuneus, of that city, happened one day, while repeating some experiments which had been originally suggested by M. Von Kleist, Dean of the Cathedral in Camin, to hold in one hand a glass vessel, nearly full of water, into which he had been sending a charge from an electrical machine, by means of a wire dipped into it, and communicating with the prime conductor, or insulated non-electric, exposed in the manner we have already mentioned to the action of the excited cylinder. He was greatly surprised, upon applying his other hand to disengage the wire from the conductor, when he thought that the water had acquired as much electricity as the machine could give it, by receiving a sudden shock in his arms and breast, much more severe than any thing of the kind he had previously encountered in the course of his experiments. The same thing, it was found, took place when the glass was covered, both within and without, with any other conductors than the water and the human hand, which had been used in this instance; as, for example, when it was coated on both sides with tinfoil, in such a manner, however, that the two coatings were completely separated from each other, by a space around the lip of the vessel being left uncovered. Whenever a communication was formed by the interposition of a conducting medium between the inside and outside coating, an instant and loud explosion took place, accompanied with a flash of light, and the sensation of a sharp blow, if the conductor employed was any part of the human body.

The first announcement of the wonders of the Leyden phial excited the curiosity of all Europe. The accounts given of the electric shock by those who first experiencd it are perfectly ludicrous, and well illustrate how strangely the imagination is acted upon by surprise and terror, when novel or unexpected results suddenly come upon it.

From the original accounts, as Dr. Priestley observes, could we not have repeated the experiment, we should have formed a very different idea of the electric shock to what it really is, even when given in greater strength than it could have been by those early experimenters. It was this experiment, however, that first made electricity a subject of general curiosity. Every body was eager, notwithstanding the alarming reports that were spread of it, to feel the new sensation; and in the same year in which the experiment was first made at Leyden, numbers of persons, in almost every country in Europe, obtained a livelihood by going about and showing it.

The particulars, then, that we have enumerated may be said to have constituted the whole of the science of Electricity, in the shape in which it first presented itself to the notice of Dr. Franklin. In the way in which we have stated them, they are little more, the reader will observe, than a mass of seemingly unconnected facts, having, at first sight, no semblance whatever of being the results of a common principle, or of being reducible to any general and comprehensive system. It is true that a theory, that of M. Dufay, had been formed before this time to account for many of them, and also for others that we have not mentioned; but it does not appear that Franklin ever heard of it until he had formed his own, which is, at all events, entirely different; so that it is unnecessary for us to take it at all into account. We shall form a fair estimate of the amount and merits of Franklin's discoveries, by considering the facts we have mentioned, as really constituting the science in the state in which he found it.

It was in the year 1746, as he tells us himself in the narrative of his life, that, being at Boston, he met with a Dr. Spence, who had lately arrived from Scotland, and who showed him some electrical experiments. They were imperfectly performed, as the doctor was not very expert; "but being," says Franklin, "on a subject quite new to me, they equally surprised and pleased me. Soon after my return to Philadelphia, our Library Company received from Mr. Peter Collinson, F. R. S., of London, a present of a glass tube, with some account of the use of it in making such experiments. I eagerly seized the opportunity of repeating what I had seen at Boston; and, by much practice, acquired great readiness in performing those also which we had an account of from England, adding a number of new ones. I say much practice, for my house was continually full for some time, with persons who came to see these new wonders. To divide a little this encumbrance among my friends, I caused a number of similar tubes to be blown in our glass house, with which they furnished themselves, so that we had at length several performers." The newly discovered and extraor

dinary phenomena exhibited by the Leyden phial of course very early engaged his attention in pursuing these interesting experiments; and his inquisitive mind immediately set itself to work to find out the reason of such strange effects, which still astonished and perplexed the ablest philosophers of Europe. Out of his speculations arose the ingenious and beautiful theory of the action of the electric influence which is known by his name: and which has ever since been received by the greater number of philosophers as the best, because the simplest and most complete, demonstration of the phenomena that has yet been given to the world.

Dr. Franklin's earliest inquiries were directed to ascertain the *source* of the electricity which friction had the effect of at least rendering manifest in the glass cylinder, or other electric. The question was, whether this virtue was created by the friction in the electric, or only thereby communicated to it from other bodies. In order to determine this point, he resorted to the very simple experiment of endeavoring to electrify himself; that is to say, having insulated himself, and excited the cylinder by rubbing it with his hand, he then drew off its electricity from it in the usual manner into his own body. But he found that he was not thereby electrified at all, as he would have been by doing the same thing, had the friction been applied by another person. No spark could be obtained from him, after the operation, by the presentment of a conductor; nor did he exhibit on such bodies as were brought near him any of the other usual evidences of being charged with electricity.

If the electricity had been created in the electric by the friction, it was impossible to conceive why the person who drew it off should not have been electrified in this case, just as he would have been had another person acted as the rubber. The result evidently indicated that the friction had effected a change upon the person who had performed that operation, as well as upon the cylinder, since it had rendered him incapable of being electrified by a process by which, in other circumstances, he would have been so. It was plain, in short, that the electricity had passed, in the first instance, out of his body into the cylinder; which, therefore, in communicating it to him in the second instance, only gave him back what it had received, and, instead of electrifying him, merely restored him to his usual state—to that in which he had been before the experiment was begun.

This accordingly was the conclusion to which Franklin came; but, to confirm it, he next insulated two individuals, one of whom he made to rub the cylinder, while the other drew the electricity from it. In this case, it was not the latter merely that was

affected; both were electrified. The one had given out as much electricity to the cylinder in rubbing it, as the other had drawn from it. To prove this still farther, he made them touch one another, when both were instantly restored to their usual state, the redundant electricity thrown off by the one exactly making up the deficiency of the other. The spark produced by their contact was also, as was to have been expected, greater than that which took place when either of them was touched by any third person who had not been electrified.

Proceeding upon the inferences which these results seemed so evidently to indicate, Franklin constructed the general outlines of his theory. Every body in nature he considered to have its natural quantity of electricity, which may, however, be either diminished, by part of it being given out to another body, as that of the rubber, in the operation of the electrical machine, is given out to the cylinder; or increased, as when the body is made to receive the electricity from the cylinder. In the one case he regarded the body as *negatively*, in the other as *positively*, electrified. In the one case it had less, in the other more, than its natural quantity of electricity: in either, therefore, supposing it to be composed of electricity and common matter, the usual equilibrium or balance between its two constituent ingredients was, for the time, upset or destroyed.

But how should this produce the different effects which are observed to result from the action of electrified bodies? How is the mere circumstance of the overthrow of the customary equilibrium between the electricity and the matter of a body to be made to account for its attraction and repulsion of other bodies, and for the extraordinary phenomena presented by the Leyden phial? The Franklinian theory answers these questions with great ease and completeness.

The fundamental law of the electric fluid, according to this theory, is, that its particles attract matter, and repel one another. To this we must add a similar law with regard to the particles of matter, namely, that they repel each other, as well as attract electricity. This latter consideration was somewhat unaccountably overlooked by Franklin; but was afterwards introduced by Mr. Æpinus, of Petersburg, and the late celebrated Mr. Cavendish, in their more elaborate expositions of his theory of the electrical action. Let us now apply these two simple principles to the explanation of the facts we have already mentioned.

In the first place, when two bodies are in their ordinary or natural state, the quantity of matter is an exact balance for the quantity of electricity in each, and there is accordingly no tendency

of the fluid to escape; no spark will take place between two such bodies when they are brought into contact. Nor will they either attract or repel each other, because the attractive and repulsive forces operating between them are exactly balanced, the two attractions of the electricity in the first for the matter in the second, and of the electricity in the second for the matter in the first, being opposed by the two repulsions of the electricity in the first for the electricity in the second, and of the matter in the first for the matter in the second. They, therefore, produce no effect upon each other whatever.

But let us next suppose that one of the bodies is an electric which has been excited in the usual way by friction, a stick of wax, or a glass cylinder, for example, which has been rubbed with the hand, or a piece of dry silk. In this case, the body in question has received an addition to its natural quantity of electricity, which addition, accordingly, it will most readily part with whenever it is brought into contact with a conductor. But this is not all. Let us see how it will act, according to the law that has been stated, upon the other body, which we shall suppose to be in its natural state, when they are brought near each other. First, from the repulsive tendency of the electric particles, the extra electricity in the excited body will drive away a portion of the electricity of the other from its nearest end, which will thus become negatively electrified, or will consist of more matter than is necessary to balance its electricity. In this state of things, what are the attractive and repulsive forces operating between the two bodies, the one, be it remembered, having an excess of electricity, and the other an excess of matter? There are, in fact, five attractive forces opposed by only four repulsive; the former being those of the matter in the first body for the electricity in the second, of the balanced electricity in the first for the balanced matter in the second, of the same for the extra matter in the second, together with the two of the extra electricity in the first for the same two quantities of matter; and the latter being those of the matter in the first for the balanced matter in the second, of the same for the extra matter in the second, together with those of the electricity in the second both for the balanced and the extra electricity in the first. The two bodies, therefore, ought to meet, as we find they actually do. But no sooner do they meet than the extra electricity of the first, attracted by the matter of the second, flows over partly to it; and both bodies become positively electrified; that is to say, each contains a quantity of electricity beyond that which its matter is capable of balancing. It will be found, upon examination, that we have now four powers of attraction opposed by five of repul

sion; the former being those of the matter in each body for the two electricities in the other, the latter those exerted by each of the electricities in the one against both the electricities of the other, together with that of the matter in the one for the matter in the other. The bodies now accordingly should repel each other, just as we find to be the fact. Of course the same reasoning applies to the case of a neutral body, and any other containing a superabundance of electricity, whether it be an electric or no, and in whatever way its electricity may have been communicated to it. We may add that there is no case of attraction or repulsion between two bodies, in which the results indicated by the theory do not coincide with those of observation as exactly as in this.

We now come to the phenomena of the Leyden phial. The two bodies upon which we are here to fix our attention are the interior and exterior coatings, which, before the process of charging has commenced, are of course in their natural state, each having exactly that quantity of electricity which its matter is able to balance, and neither therefore exerting any effect whatever upon the other. But no sooner has the interior coating received an additional portion of electricity from the prime conductor, with which the reader will remember it is in communication, than, being now positively electrified, it repels a corresponding portion of its electricity from the exterior coating, which therefore becomes negatively electrified. As the operation goes on, both these effects increase, till at last the superabundance of electricity in the one surface, and its deficiency in the other, reach the limit to which it is wished to carry them. All this while, it will be remarked, the former is prevented from giving out its superfluity to the latter by the interposition of the glass, which is a non-conductor, and the uncovered space which had been left on both sides around the lip of the vessel. If the charge were made too high, however, even these obstacles would be overcome, and the unbalanced electricity of the interior coating, finding no easier vent, would at last rush through the glass to the unsaturated matter on its opposite surface, probably shattering it to pieces in its progress. But, to effect a discharge in the usual manner, a communication must be established by means of a good conductor between the two surfaces, before this extreme limit be reached. If either a rod of metal, for example, or the human body, be employed for this purpose, the fluid from the interior coating will instantly rush along the road made for it, occasioning a pretty loud report, and, in the latter case, a severe shock, by the rapidity of its passage. Both coatings will, in consequence, be immediately restored to their natural state.

That this is the true explanation of the matter Franklin further demonstrated by a variety of ingenious experiments. In the first place, he found that, if the outer coating was cut off, by being insulated from every conducting body, the inner coating could not be charged; the electricity in the outer coating had here no means of escape, and it was consequently impossible to produce in that coating the requisite negative electricity. On the other hand, if a good conductor was brought within the striking distance from the outside coating, while the process of charging was going on, the expelled fluid might be seen passing away towards it in sparks, in proportion as more was sent from the prime conductor into the inside of the vessel. He observed also that, when a phial was charged, a cork ball, suspended on silk, would be attracted by the one coating when it had been repelled by the other—an additional indication and proof of their opposite states of electricity, as might be easily shown by an analysis of the attractive and repulsive forces operating between the two bodies in each case.

But Franklin did not rest contented with ascertaining the principle of the Leyden phial. He made also a very happy application of this principle, which afforded a still more wonderful manifestation than had yet been obtained of the powers of accumulated electricity. Considering the waste that took place, in the common experiment, of the fluid expelled, during the process of charging, from the exterior coating, he conceived the idea of employing it to charge the inner surface of a second jar, which he effected, of course, by the simple expedient of drawing it off by means of a metal rod communicating with that surface. The electricity expelled from the outside of this second jar was conveyed, in like manner, into the inside of a third; and, in this way, a great number of jars were charged with the same facility as a single one. Then, having connected all the inside coatings with one conductor, and all the outside coatings with another, he had merely to bring these two general conductors into contact or communication, in order to discharge the whole accumulation at once. This contrivance he called an *electrical battery.*

The general sketch we have just given will put the reader in possession, at least, of the great outlines of the Franklinian theory of electricity, undoubtedly one of the most beautiful generalizations to be found in the whole compass of science. By the aid of what we may call a single principle, since the law with regard to the electric fluid and common matter is exactly the same, it explains satisfactorily not only all the facts connected with this interesting subject which were known when it was first proposed, but all those that have been since discovered, diffusing order and light through-

out what seemed before little better than a chaos of unintelligible contradictions. We must now, however, turn to a very brilliant discovery of this illustrious philosopher, the reality of which does not depend upon the truth or falsehood of any theory.

Franklin was by no means the first person to whom the idea had suggested itself of a similarity between electricity and lightning. Not to mention many other names which might be quoted, the Abbé Nollet had, before him, not only intimated his suspicion that thunder might be in the hands of Nature what electricity is in ours, but stated a variety of reasons on which he rested his conjecture. It is to Franklin alone, however, that the glory belongs of both pointing out the true method of verifying this conjecture, and of actually establishing the perfect identity of the two powers in question. "It has, indeed, been of late the fashion," says the editor of the first account of his electrical experiments, published at London in 1751, "to ascribe every grand or unusual operation of nature, such as lightning and earthquakes, to electricity; not, as one would imagine from the matter of reasoning on these occasions, that the authors of these schemes have discovered any connection betwixt the cause and effect, or saw in what manner they were related; but, as it would seem, merely because they were unacquainted with any other agent, of which it could not positively be said the connection was impossible." Franklin transformed what had been little more than a figure of rhetoric into a most important scientific fact.

In a paper, dated November 7, 1749, he enumerates all the known points of resemblance between lightning and electricity. In the first place, he remarks, it is no wonder that the effects of the one should be so much greater than those of the other; for if two gun-barrels electrified will strike at two inches distance, and make a loud report, at how great a distance will ten thousand acres of electrified cloud strike, and give its fire; and how loud must be that crack! He then notices the crooked and waving course, both of the flash of lightning, and, in some cases, of the electric sparks; the tendency of lightning, like electricity, to take the readiest and best conductor; the facts that lightning, as well as electricity, dissolves metals, burns some bodies, rends others, strikes people blind, destroys animal life, reverses the poles of magnets, &c.

He had known for some time the extraordinary power of pointed bodies, both in drawing and in throwing off the electric fire. The true explanation of this fact did not occur to him; but it is a direct consequence of the fundamental principle of his own theory, according to which the repulsive tendency of the particles of electricity towards each other, occasioning the fluid to retire, in every

case, from the interior to the surface of bodies, drives it with especial force towards points and other prominences, and thus favors its escape through such outlets; while, on the other hand, the more concentrated attraction which the matter of a pointed body, as compared with that of a blunt one, exerts upon the electricity to which it is presented, brings it down into its new channel in a denser stream. In possession, however, of the fact, we find him concluding the paper we have mentioned as follows:—"The electric fluid is attracted by points. We do not know whether this property be in lightning; but since they agree in all the particulars in which we can already compare them, it is not improbable that they agree likewise in this. Let the experiment be made."

Full of this idea, it was yet some time before he found what he conceived a favorable opportunity of trying its truth in the way he meditated. A spire was about to be erected in Philadelphia, which he thought would afford him facilities for the experiment; but his attention having been one day drawn by a kite which a boy was flying, it suddenly occurred to him, that here was a method of reaching the clouds preferable to any other. Accordingly, he immediately took a large silk handkerchief, and stretching it over two cross sticks, formed in this manner his simple apparatus for drawing down the lightning from its cloud. Soon after, seeing a thunder-storm approaching, he took a walk into a field in the neighborhood of the city in which there was a shed, communicating his intentions, however, to no one but his son, whom he took with him, to assist him in raising the kite: this was in June, 1752.

The kite being raised, he fastened a key to the lower extremity of the hempen string, and then insulating it by attaching it to a post by means of silk, he placed himself under the shed, and waited the result. For some time no signs of electricity appeared. A cloud, apparently charged with lightning, had even passed over them without producing any effect. At length, however, just as Franklin was beginning to despair, he observed some loose threads of the hempen string rise and stand erect, exactly as if they had been repelled from each other by being charged with electricity. He immediately presented his knuckle to the key, and, to his inexpressible delight, drew from it the well-known electrical spark. It is said that his emotion was so great at this completion of a discovery which was to make his name immortal, that he heaved a deep sigh, and felt that he could that moment have willingly died. As the rain increased, the cord became a better conductor, and the key gave out its electricity copiously. Had the hemp been

thoroughly wet, the bold experimenter might, as he was contented to do, have paid for his discovery with his life.

He afterwards brought down the lightning into his house, by means of an insulated iron rod, and performed with it, at his leisure, all the experiments that could be performed with electricity. But he did not stop here. His active and practical mind was not satisfied even with the splendid discovery, until he had turned it to a useful end. There was always a strong tendency in Franklin's philosophy to these practical applications. The lightning-rod was probably the result of some of the amusing experiments with which Franklin was, at the commencement of his electrical investigations, accustomed to employ his own leisure, and afford pleasure to his friends. In one of his letters to Mr. Collinson, dated so early as 1748, we find him expressing himself in the following strain, in reference to his electrical experiments :—" Chagrined a little that we have hitherto been able to produce nothing in this way of use to mankind, and the hot weather coming on, when electrical experiments are not so agreeable, it is proposed to put an end to them for this season somewhat humorously, in a party of pleasure on the banks of the *Schuylkill*. Spirits at the same time are to be fired by a spark sent from side to side through the river, without any other conductor than the water—an experiment which we have some time since performed to the amazement of many. A turkey is to be killed for dinner by the *electrical shock*, and roasted by the *electrical jack*, before a fire kindled by the *electrical bottle ;* when the healths of all the famous electricians in *England*, *Holland*, *France*, and *Germany*, are to be drunk in *electrified bumpers*, under the discharge of guns from the *electrical battery*."

Franklin's electrical discoveries did not, on their first announcement, attract much attention in England ; and, indeed, he had the mortification of learning that his paper on the similarity of lightning to electricity, when read by a friend to the Royal Society, had been only laughed at by that learned body. In France, however, the account that had been published in London of his experiments, fortunately fell into the hands of the celebrated naturalist, Buffon, who was so much struck with it, that he had it translated into French, and printed at Paris. This made it immediately known to all Europe ; and versions of it in various other modern languages soon appeared, as well as one in Latin. The theory propounded in it was at first violently opposed in France by the Abbé Nollet, who had one of his own to support, and, as Franklin tells us, could not at first believe that such a work came from America ; but said it must have been fabricated by his enemies at Paris. The Abbé

was eventually, however, deserted by all his partisans, and lived to see himself the last of his sect. In England, too, the Franklinian experiments gradually began to be more spoken of; and, at last, even the Royal Society was induced to resume the consideration of the papers that had formerly been read to them. One of their members verified the grand experiment of bringing down lightning from the clouds; and upon his reading to them an account of his success, "they soon," says Franklin, "made me more than amends for the slight with which they had before treated me. Without my having made any application for that honor, they chose me a member; and voted that I should be excused the customary payments, which would have amounted to twenty-five guineas; and ever since have given me their transactions gratis. They also presented me with the gold medal of Sir Godfrey Copley, for the year 1753, the delivery of which was accompanied with a very handsome speech of the president, Lord Macclesfield, wherein I was highly honored." Some years afterwards, when he was in Great Britain with his son, the University of St. Andrew's conferred upon him the degree of Doctor of Laws; and its example was followed by the Universities of Edinburgh and Oxford. He was also elected a member of many of the learned societies throughout Europe.

No philosopher of the age now stood on a prouder eminence than this extraordinary man, who had originally been one of the most obscure of the people, and had raised himself to all this distinction almost without the aid of any education but such as he had given himself. Who will say, after reading his story, that any thing more is necessary for the attainment of knowledge than the determination to attain it?—that there is any other obstacle to even the highest degree of intellectual advancement which may not be overcome, except a man's own listlessness or indolence? The secret of this man's success in the cultivation of his mental powers was, that he was ever awake and active in that business; that he suffered no opportunity of forwarding it to escape him unimproved; that, however poor, he found at least a few pence, were it even by diminishing his scanty meals, to pay for the loan of the books he could not buy; that, however hard-wrought, he found a few hours in the week, were it by sitting up half the night after toiling all the day, to read and study them. Others may not have his original powers of mind; but his industry, his perseverance, his self-command, are for the imitation of all: and though few may look forward to the rare fortune of achieving discoveries like his, all may derive both instruction and encouragement from his example. They who may never *overtake the light, may at least follow its path, and guide their footsteps by its illumination.*

Were we to pursue the remainder of Franklin's history, we should find the fame of the patriot vying with that of the philoso pher, in casting a splendor over it; and the originally poor and unknown tradesman standing before kings, associating as an equal with the most eminent statesmen of his time, and arranging along with them the wars and treaties of mighty nations. When the struggle for independence commenced, Franklin took a very active part. He was soon sent ambassador to the court of France, where principally through his exertions an alliance was brought about between the two countries, which produced an immediate war between the latter and England. In 1783, he signed the treaty of peace, which recognised our independence. Two years after he arrived in Philadelphia, where he was chosen president of the Supreme Executive Council of the city. He closed his eventful and honorable life on the 17th of April, 1790, in the eighty-fifth year of his age.

Franklin was in conversation sprightly, in manners bland. Destitute of pride, he considered all honest men on an equality. During the time he was in Great Britain, in the dignified station of ambassador, he went into his old printing office, and entering the press-room, proceeded to a particular press where two men were at work: "*Come, my friends,*" says he, "*we will drink together; it is now forty years since I worked like you at this press, as a journeyman printer.*" A gallon of porter was sent for, and he then drank "*success to printing.*" At a later period, the merchants in Philadelphia being desirous to establish an assembly for dancing, they drew up some rules, among which was one "that no mechanic or mechanic's wife or daughter should be admitted on any terms." This rule being submitted to Franklin, he remarked that "*it excluded God Almighty, for he was the greatest mechanic in the universe.*" An enemy to every thing aristocratic, even his eloquence partook of an unpretending character; but he developed his ideas with clearness and precision. He had always at hand an immense stock of common sense, and possessed the very useful quality of being "eminently great in little things."

OLIVER EVANS.

Birth.—Apprenticed to a wagon maker.—Fondness for study.—Penuriousness of his master.—Pursues his evening studies by the light of burning shavings.—Turns his attention to the propelling of carriages without animal power.—An experiment.—Renews his studies with increased ardor.—Is laughed at for declaring that *he* can make steam carriages.—Opinions confirmed by experiment.—Is defrauded of an invention for making card teeth.—Marries.—Enters into the milling business with his brothers.—His inventions revolutionize the manufacture of flour.—Account of those improvements.—Difficulties attending their introduction.—Opposition of the Brandywine millers.—Petitions the Legislature of Pennsylvania for the right of using his mill improvements and steam carriages.—The former granted and the latter ridiculed.—The Legislature of Maryland grant them both.—Commences a steam carriage at his own expense.—Latrobe's report.—Lays aside the carriage and builds a steam engine for mills, which reduces him to poverty.—Final success.—Constructs a machine for cleaning docks.—*First American locomotive.*—Public incredulity.—His the *first* high pressure engine.—Submits a proposition to the Lancaster turnpike company.—Predictions.—Mill improvements gradually come into use.—Violators.—Unsuccessful lawsuit.—Petitions congress for a renewal of his patents.—Memorial of his opponents.—Counter memorial.—Triumph.—His published works.—Death.

It is but seldom that the pen of the biographer has occasion to trace the memoir of an individual possessing equal perseverance, or greater originality of mechanical conception, than the subject of this memoir, who has been aptly styled "*the Watt of America.*"

Oliver Evans was born in Newport, Delaware, sometime in the year 1755 or 1756. Little is preserved respecting his early history. His parents were agriculturists of respectable standing, who gave their son the advantages common to people in their station. At the age of fourteen Evans was apprenticed to a wheelwright or wagon maker. An anecdote is preserved which displays in his character, even at this period, that ardent desire for knowledge, and that determination ever evinced not to let any obstacle interfere with the object of his pursuits. His master, an illiterate man, observing his apprentice employing his leisure evenings in study, through motives of parsimony, forbade him using candles; but young Evans was not to be discouraged, for, collecting at the close of each day the shavings made from his work, he would take them to the chimney corner, and, by their uncertain light, pursue his evening studies.

While yet an apprentice his attention was turned to the subject

of propelling land carriages without animal power; but all the methods with which he was acquainted appearing too futile to deserve an experiment, he concluded such motion to be impossible for the want of a suitable original power. But one of his brothers informed him on a Christmas evening that he had that day been in company with a neighboring blacksmith's boy, who, for amusement, had stopped up the touch-hole of a gun barrel, then pouring in a gill of water, rammed down a tight wad; after which on putting the breech in the fire, it discharged itself with a report like gunpowder. The active mind of Evans, ever awake to the phenomena around him, instantly saw that *here* was the long desired power, if he could only apply it, and from this period endeavored to discover the means. He labored for some time without success; at length a book fell into his hands describing the old atmospheric steam engine; and he was greatly astonished to observe they had so far erred as to use the steam only in forming a vacuum to apply the mere pressure of the atmosphere, instead of using the elastic force of the steam for the original motion, the power of which he supposed irresistible. He thereupon renewed his studies with increased ardor, and soon declared that *he* could make steam carriages, and endeavored to communicate his ideas to others, but was only listened to with ridicule. Persevering, his experiments confirmed his opinions; but want of means for a time compelled him to abandon its prosecution.

When twenty-three or twenty-four years of age he was engaged in making card teeth by hand, at that period the only method known. Finding this a tedious operation, he invented a machine that would manufacture three thousand a minute, but was defrauded of a great share of the benefits derived from it. Shortly after he *projected* a plan for pricking the leather in cards, and at the same time cutting, bending, and setting the teeth; but owing to the unfortunate result of the previous invention, never carried it into execution.

At the age of twenty-five Mr. Evans married a daughter of Mr. John Tomlinson, a respectable farmer of Delaware. About this period he entered into business with his brothers, who were millers, and wished to avail themselves of his talents and ingenuity. Here was an appropriate field for the display of a genius like his, and ere long was commenced those series of improvements in the construction of machinery and appurtenances of mills which effected a complete revolution in the manufacture of flour. These improvements consist of the invention and various application of the following machines, viz:—The elevator, the conveyor, the hopper-boy, the drill, and the descender, which five machines are variously

applied in different mills according to their construction, so as to perform every necessary movement of the grain and meal from one part of the mill to the other, or from one machine to another, through all the various operations, from the time the grain is emptied from the wagoner's bag, or from the measure on board the ship, until it is completely manufactured into flour, separated, and ready for packing; all of which is performed by the force of the water, without the aid of manual labor, except to set the different machines in motion. The advantages derived from these improvements are great in almost every respect, not only causing a *saving* of full *one half* in the labor of attendance, but manufacturing the flour better, and making about twenty-eight pounds of superfine flour *more* to each barrel than was made by the old method.*

These improvements were completed in theory as early as 1783, but were not carried into operation until a year or two later; and then before they perfectly succeeded, many alterations were to be made, and great difficulties to surmount. Although the result exceeded expectation, yet the opposition which was experienced rendered their introduction into general use extremely laborious. To promote this object, Mr. Evans furnished his brother with the necessary funds, and despatched him through the country to establish them. He travelled through the states of Pennsylvania, Delaware, Maryland, and Virginia, offering the inventions gratis to the first in each county who would adopt them. After considerable expense he returned wholly unsuccessful, and without any favorable prospects for the future. The Brandywine millers in particular opposed their adoption with all their influence, until they were in use in several mills around them. At length they held a consultation, and deputed one of their number to Mr. Evans to make proposals as to the terms on which they would try the experiment, which were nearly in the words following, viz: "Oliver, we have had a meeting, and agreed that if thou would furnish all the materials, and thy own boarding, and come thyself to set up the machinery, in one of our mills, thee may come and try, and if it answers a valuable purpose, we will pay thy bill, but if it does not answer, thee must take it all out again, and leave the mill just as thee finds it, at thy own expense." The principles having already been tested, and these millers knowing Mr. Evans' reduced circumstances at the

* When Mr. Evans' milling improvements came into popular use, it was estimated that at Ellicott's mills, near Baltimore, where three hundred and twenty-five barrels of flour were daily manufactured, that in expense of attendance alone, there was an annual saving of *four thousand eight hundred and seventy-five dollars*, and that the saving made by the increased amount manufactured, was at least fifty cents a barrel, amounting to a gain in this department of *thirty-two thousand five hundred dollars!*

time, he could but regard their propositions as a disposition to retard and embarrass rather than to encourage or forward the improvement.

The following anecdotes which were related by Mr. Evans, exhibit a strength of prejudice, on the part of these men, almost inconceivable. When he had his inventions in full operation, so that he could alone attend his mill with less fatigue than he could before, even with the assistance of two men and a boy, he invited the Brandywine millers to come and witness its operation. It so happened that some of them called on a day when he had alone, both to attend the mill and make hay in an adjoining clover lot. On seeing their approach, he turned from them, thinking it best to let them enter the mill, and finding it attending to itself, would be convincing and positive proof of the great utility of the improvements. Entering, they found all the operations of cleaning, grinding, and bolting going on without the intervention of a human hand, with perfect regularity and despatch. In about half an hour, they came to Mr. Evans, and requested him to explain the whole of the operations, which he did willingly, but took care to inform them that it was an "uncommon busy" day with him, for he had both to attend the mill and make hay. After they left, Mr. Evans returned to the lot, leaving the mill to attend itself, and rejoicing at the lucky circumstance, not doubting but they were *now* fully convinced. But to his astonishment, he soon learned that on their return, they had reported to their neighboring millers, that the whole contrivance was a set of "*rattle traps*," not worthy the attention of men of common sense; which fixed more firmly the opposition of the rest to the adoption of the improvement. Some time later, he exhibited a model of his improved mill in the streets of Wilmington, Delaware, which was to be sent to England. Some of the crowd called to a Brandywine miller, as he happened to be passing, who was so struck with its simplicity and perfection, together with the observations of those present, that he contracted with the inventor to construct one for him. It was soon put into operation in presence of the neighboring millers; and though the elevators and conveyors, without the aid of human hands, brought the meal from the two pair of stones, and the tail-flour from the bolts to the hopper-boy, which spread it over the floor, stirring, fanning, and gathering it, and attending the bolting hoppers at the same time, yet one of them, in contradiction to the evidence of his own senses, exclaimed, "It will not do!—it cannot do!—it is impossible it should do!"

The opposition of these millers cost him thousands of dollars in fruitless attempts to establish his inventions. Wherever his agents went, the inquiry was, "Have the Brandywine millers adopted

them?" The answer was of course, "No!" which was generally followed by this pertinent reply: "If those who are so much more extensively engaged in the manufacture of flour do not think them worthy their attention, they cannot certainly demand ours." This treatment on the part of these men recoiled upon themselves, and their obstinacy was such in adopting the improvements, that the mills on the Brandywine for a time lost their pre-eminence.

In the year 1786, Mr. Evans petitioned the legislature of Pennsylvania for the exclusive right to use his improvements in flour mills, and steam carriages, in that state, and in the year following presented a similar petition to the legislature of Maryland. In the former instance he was only successful so far as to obtain the privilege of the mill improvements; his representations concerning steam carriages were considered as savoring too much of insanity to deserve notice. He was more fortunate in Maryland, for, although the steam project was laughed at, yet one of his friends, a member, very judiciously observed that the grant could injure no one, for he did not think that any man in the world had thought of such a thing before, he therefore wished the encouragement might be afforded, as there was a prospect that it would produce something useful. This kind of argument had its effect, and Evans received all that he asked for, and from that period considered himself bound in honor to the state of Maryland to produce a steam carriage, as soon as his means would allow him.

For several years succeeding the granting of his petition by the legislature of Maryland, Mr. Evans endeavored to obtain some person of pecuniary resources to join with him in his plans; and for this purpose explained his views by drafts, and otherwise, to some of the first mechanics in the country: although they appeared in several instances to understand them, yet declined any assistance from a fear of the expense and difficulty of their execution.*

In the year 1800 or 1801, Mr. Evans, never having found any one willing to contribute to the expense, or even to encourage him in his efforts, determined to construct a steam carriage at his own expense. Previous to commencing he explained his views to Robert Patterson, professor of mathematics in the University of Pennsylvania, and to an eminent English engineer. They both de-

* I certify that Oliver Evans did, about the year 1789, communicate a project to me of propelling land carriages by the power of steam, and did solicit me to join with him in the profits of the same. LEVI HOLLINGSWORTH.
Baltimore, *Nov.* 16, 1812.

I do certify that about 1781, (thirty-one years ago,) Oliver Evans, in conversation with me, declared that by the power of steam he could drive any thing; wagons, mills, or vessels by the same power. ENOCH ANDERSON.
November 15, 1812.

clared the principles new to them, and advised the plan, as highly worthy of a fair experiment. These were the only persons who had any confidence, or afforded encouraging advice. He also communicated his plans to Mr. B. F. Latrobe, a highly scientific gentleman, who publicly pronounced them as chimerical, and attempted to demonstrate the absurdity of Mr. Evans' principles in his report to the Philosophical Society of Pennsylvania, on steam engines: in which he also endeavored to show the impossibility of making steamboats useful. In this report, Mr. Evans is one of the persons alluded to, as being seized with the "*steam mania*," but the liberality of the society caused them to reject that portion of the paper, conceiving that they had no right to set up their opinions as an obstacle in the way of any exertions to make a discovery, although they did not reject that gentleman's demonstrations respecting steamboats.

In consequence of the determination previously alluded to, Mr. Evans commenced and had made considerable progress in the construction of a steam carriage, when the idea occurred to him, that as his steam engine was altogether different in form, as well as in principle, from any other in use, a patent could be obtained for it, and then applied to mills, more profitably than to carriages. The steam carriage was accordingly laid aside for a season of more leisure, and the construction of a small engine was commenced, with a cylinder six inches in diameter, and piston of eighteen inches stroke, for a mill to grind plaster of Paris. The expense of its construction far exceeded Mr. Evans' calculations, and before the engine was finished he found it cost him all he was worth. He had then to begin the world anew, at the age of forty-eight, with a large family to support, and that too with a knowledge, that if the trial failed his credit would be entirely ruined, and his prospects for the remainder of life dark and gloomy. But fortune favored him, and his success was complete.

In a brief account given by himself of his experiments in steam, he says, "I could break and grind three hundred bushels of plaster of Paris, or twelve tons, in twenty-four hours; and to show its operations more fully to the public, I applied it to saw stone, on the side of Market-street, where the driving of twelve saws in heavy frames, sawing at the rate of one hundred feet of marble in twelve hours, made a great show and excited much attention. I thought this was sufficient to convince the thousands of spectators of the utility of my discovery, but I frequently heard them inquire if the power could be applied to saw timber, as well as stone, to grind grain, propel boats, &c., and though I answered in the affirmative, they still doubted. I therefore determined to apply my

engine to all new uses; to introduce it and them to the public. This experiment completely tested the correctness of my principles. The power of my engine rises in a geometrical proportion, while the consumption of fuel has only an arithmetical ratio; in such proportion that every time I added one fourth more to the consumption of the fuel, its powers were doubled; and that twice the quantity of fuel required to drive one saw, would drive sixteen saws at least; for when I drove two saws the consumption was eight bushels of coal in twelve hours, but when twelve saws were driven, the consumption was not more than ten bushels; so that the more we resist the steam, the greater is the effect of the engine. On these principles very light but powerful engines can be made suitable for propelling boats and land carriages, without the great encumbrance of their weight as mentioned in Latrobe's demonstration."

In the year 1804, Mr. Evans, by order of the board of health of Philadelphia, constructed at his works, situated a mile and a half from the water, a machine for cleaning docks.* It consisted of a large flat or scow, with a steam engine of the power of five horses on board, to work machinery, in raising the mud into scows. This was considered a fine opportunity to show the public that his engine could propel both land and water conveyances. When the machine was finished, he fixed, in a rough and temporary manner, wheels with wooden axletrees, and of course, under the influence of great friction. Although the whole weight was equal to two hundred barrels of flour, yet his small engine propelled it up Market-street, and round the circle to the water works, where it was launched into the Schuylkill. A paddle wheel was then applied to its stern, and it thus sailed down that river to the Delaware, a distance of sixteen miles, leaving all vessels that were under sail at least half way, (the wind being ahead,) in the presence of thousands of spectators, which he supposed would have convinced them of the practicability of steamboats and steam carriages. But no allowance was made by the public for the disproportion of the engine to its load, nor for the rough manner in which the machinery was fixed, or the great friction and ill form of the boat, but it was supposed that this was the utmost it could perform. Some individuals undertook to ridicule this experiment of driving so great a weight on land, because the motion was too slow to be useful. The inventor silenced them by answering that he would make a carriage propelled by steam, for a wager of three thousand dollars, to run upon a level road, against the swiftest horse that could be produced. This machine Evans named the Oructor Amphibolis, which is

* This was the first applicatio to the important but now common operation of dredging.—*American edition of Wood's Treatise on Rail Roads.*

believed to have been the *first application, in America, of steam power to the propelling of land carriages.*

On the 25th of September, 1804, Evans submitted to the consideration of the Lancaster turnpike company, a statement of the costs and profits of a steam carriage to carry one hundred barrels of flour, fifty miles in twenty-four hours; tending to show, that one such steam carriage would make more nett profits than ten wagons, drawn by five horses each, on a good turnpike road, and offering to build one at a very low price. His address closed as follows: "It is too much for an individual to put in operation every improvement which he may invent. I have no doubt but that my engines will propel boats against the current of the Mississippi, and wagons on turnpike roads, with great profit. I now call upon those whose interest it is, to carry this invention into effect. All which is respectfully submitted to your consideration." Little or no attention was paid to the offer.

Had Evans received the patronage and pecuniary assistance that fell to the lot of Fulton, there is no doubt but he might have shown steamboats in operation fifteen or twenty years previous to the successful experiments of that ingenious individual. This probability is strengthened by the fact, that his engine, *the first* ever invented on the high-pressure principle*, is the only one that can be applied on railways, and is now in universal use on the Mississippi† and other rapid rivers, where great power is required.

* "It is scarcely necessary to mention to the American reader, that the claim respecting the high pressure steam and locomotive engines to which the English assert, is entirely without foundation. The application of steam in this manner and to these purposes had, indeed, been contemplated, but never reduced to practice until the experiments alluded to. In early life, Mr. Evans sent Mr. Joseph Sampson to England with the drawings and specifications of his steam engines, &c. They were exhibited to numerous engineers, and his plans were copied by Messrs. Vivian and Trevithick, without any acknowledgment: the latter persons acquired fame and fortune, while the ingenious, but eccentric Evans, died poor, neglected, and broken-hearted. Fitch, Fulton, and Evans, exhibit a singular coincidence in their history. Posterity will, at least, render them the tardy recompense of justice. *America may, therefore, claim the invention of locomotive engines* with even more justice than that of steamboats,—inventions which are destined to revolutionize the commerce and defence of nations."—*Amer. Edit. of Wood's Treatise on Railroads.*

† "Mr. Evans wrote in 1802 to gentlemen in Kentucky, informing them he had got his engine in motion, which he had long before invented, for propelling boats and carriages. These letters were shown to Captain James M'Keaver, who associated with Mr. Louis Valcourt, to build a steamboat to ply between New Orleans and Natchez. Valcourt came to Philadelphia to employ Mr. Evans to make a steam engine, while the captain should build a boat eighty feet keel, and eighteen feet beam. Two of Mr. Evans' company of workmen went with the engine to meet the boat at New Orleans, to set it up, which they completed, and the boat was ready for experiment; but by this time the water had subsided, and left the boat half a mile from the water: their money being expended, their credit exhausted, and the river not expected to rise in less than six months! In

While Evans' conceptions respecting the power of steam reflect the highest credit upon his sagacity and talent, his predictions of its application may well be termed prophetic. In some of his writings, published in the early part of the present century, he remarks: "The time will come when people will travel in stages, moved by steam engines, from one city to another, almost as fast as birds fly, fifteen or twenty miles an hour. Passing through the air with such velocity, changing the scene in such rapid succession, will be the most rapid exhilarating exercise. A carriage (steam) will set out from Washington in the morning, the passengers will breakfast at Baltimore, dine at Philadelphia, and sup in New York the same day. To accomplish this, two sets of railways will be laid, so nearly level as not in any way to deviate more than two degrees from a horizontal line, made of wood or iron, or smooth paths of broken stone or gravel, with a rail to guide the carriages so that they may pass each other in different directions, and travel by night as well as by day. Engines will drive boats ten or twelve miles per hour, and there will be many hundred steamboats running on the Mississippi, as predicted years ago."

After a lapse of years, as the improvements in the manufacture of flour gradually came into popular use, the inducements to infringe upon Evans' rights increased, until he was obliged to appeal for redress to the United States circuit court of Pennsylvania, but, through some informality in the patent, an unfavorable decision was given. Thus was he deprived of all means of recovering what was so justly due. Agreeably to the request of counsel, he then petitioned congress for a new patent. In stating his case, he observed, "that he had been at a great expense in publishing and disseminating these inventions, travelling either by himself or agents

this predicament, Mr. William Donaldson offered them money to take the engine out of the boat, and set it to drive a saw-mill, that could go only by the waters of the river overflowing its banks, and was then standing. Their necessities compelled them to accept the offer. When they got the saw-mill going, they wrote that to their astonishment the engine was sawing three thousand feet of boards per day of twelve hours, which had been selling at the enormous price of fifty to sixty dollars per one thousand feet; that they were now convinced there could be no doubt that the steamboat would have succeeded beyond their expectations; that they would soon retrieve their losses, and would order another engine for the boat. But, alas! their fair prospects were soon blasted; for there, too, were some of the wise opposers of improvements. This mill was likely to deprive some who sawed lumber by hand of profitable jobs, and it was set on fire; the two first attempts the fire was discovered in time to be extinguished; but in the third, those *infernal* incendiaries had like to have succeeded not only in destroying the mill, but with it those who had slept in it, to guard it. Thus were two noble and enterprising men ruined, in the most laudable attempts to establish steamboats on the Mississippi. They had expended fifteen thousand dollars, and would have succeeded three or four years before Fulton and Livingston, but for the reasons above stated."—*Patent Right Oppression Exposed.*

for thirteen years, throughout the country, from state to state, and from mill to mill, to instruct workmen in their manufacture, and millers their use: and in this way had expended the small fees which were received from those who had generously and freely paid for their license." These arguments were so clearly founded on justice, that government could not but listen to his claims, and the petition was granted, January 21, 1808.

Ere long, a memorial was presented to congress by John Worthington, Elisha Tyson, and other interested millers, against Oliver Evans, stating "that the public had been grossly deceived in regard to Evans being the original inventor of his patented mill machines; for, so far from having invented ALL, he was not the original inventor of any of them: and that they could not believe that those in authority intended to let loose upon the community this exorbitant monopolist with so grievous and despotic a power. They therefore petitioned to have the subject once more taken into consideration." Evans immediately presented a counter memorial, in which he completely proved the falsity of their statements, and the interested motives of his opponents. Independent of this, some of the most prominent* individuals in the community, on this and other occasions, came forward unsolicited with their testimony in his behalf. In the result, Evans was sustained.

* The following, among other statements, was furnished by the well-known editor of Niles' Register, on the occasion of some of Mr. Evans' lawsuits:—

"The subscriber, unsolicited by, and unknown to Oliver Evans, feels it due to truth and justice to state his recollections of the mill machinery. He well remembers, when at the Brandywine mills, they used to hoist the flour from the lower story to the loft, in large buckets or tubs, filled by shovels from the chests into which the flour fell from the millstones: he has also frequently seen a man employed at these mills in heaping the flour over the *hopper* to let it pass into the bolting cloth below. Born in the neighborhood of these mills, and passing his infancy and youth at Wilmington, within half a mile of them; and going there to swim and to skate, as well as for other juvenile amusements, the place presenting delightful advantages for their enjoyment, he has passed through those mills, or some of them, many hundred times before and since the improvements were introduced. His young mind was much pleased to observe the little buckets (the *elevator*,) supplying the place of the large one, above alluded to; and he was much amused to see the labors of the *hopper-boy*, that spread, cooled, and collected the meal, without manual labor, to the spot where it was wanted; nor was he less agreeably surprised at the operation of the *conveyor*, that, while it cooled the flour, passed it on to the place where the *elevator* caught it. He also recollects to have heard it stated that the introduction of this machinery would throw more than twenty persons out of employ at Brandywine; and always understood that these *innovations* on the old mode of manufacturing flour were made by Oliver Evans.

"While writing the above, an old *schoolmate* is at my elbow, who has precisely the same recollections. Neither of us pretend to know that Oliver Evans really invented those things; but are certain that *common fame* gave him the credit of them at the time they were introduced at the Brandywine mills.

"H. NILES,

"*Baltimore, Feb.* 10, 1813." "*Editor of the Register.*"

A few years subsequent to his marriage, Mr. Evans removed to Philadelphia, where he finally established an iron foundry and steam factory. Here he prepared his two works for the press, viz. the Young Millwright's and the Young Steam Engineer's Guides,—productions every way worthy of their author. In 1810, his two sons-in-law, Messrs. James Rush and David Muhlenburg, joined and continued in business with him until the time of his decease, which took place from an inflammation of the lungs, April 21st, 1819.

SAMUEL SLATER,

THE FATHER OF THE AMERICAN COTTON MANUFACTURES.

Birth.—Is apprenticed to the partner of Arkwright in the business of cotton spinning.—Fondness for experiments in machinery.—Improves the "heart motion."—Industry.—Appointed overseer.—Anecdote.—Forms the idea of coming to America.—Is obliged to leave secretly.—Adventures in London.—Sails for the United States.—Obtains a temporary employment.—Dispiriting results of the attempts to establish the cotton manufacture previous to his arrival.—Applies to Moses Brown.—Visits Pawtucket.—Enters into the cotton business with Messrs. Almy and Brown.—Low state of manufactures.—Disappointment.—Agrees to erect the Arkwright patents.—Affecting anecdote.—Forms a tender attachment.—Builds the "Old Mill" at Pawtucket.—Prejudice.—Prosperity.—Extension of the cotton manufacture.—Establishes the first American Sunday school.—Character.—Conclusion of his domestic history.—Death.—Tribute to his memory.

We, of the present day, in witnessing the extent and variety of our manufactures, can scarcely realize the low state in which they were, some forty or fifty years since: nor, without investigation, can we form any conception of the difficulties incident to their establishment. In none were they so formidable as in the cotton manufacture: and it is judged that *he*, who forsook the endearments of home for a land of strangers, to seek its establishment among us, certainly claims a place amid the other characters that comprise this volume.

The subject of this memoir* was born at Belper, in Derbyshire, England, June 9, 1768. His father was one of those independent yeomanry who farm their own lands, forming a distinct class from the tenantry. Young Slater received the advantages of an ordinary English education; and while at school, manifested a general fondness for study, but more particularly for that of arithmetic, one by far the most important in disciplining the mind for the business of life—a talent almost universal with those who become distinguished for mechanical ingenuity.

The cotton spinning business, at this time in its infancy, was carried on in the neighborhood by Jedediah Strutt, the partner of

* See White's "Memoir of Slater; connected with a History of the Rise and Progress of the Cotton Manufacture in England and America: with Remarks on the Moral Influence of Manufactories in the United States;"—a work containing a great deal of valuable and interesting information.

the celebrated Arkwright. Mr. Slater having frequent intercourse with Mr. Strutt, made an agreement with him to take his son into his employment. In August of the same year, young Slater lost his father; and thus, at the early age of fourteen, was left his own master. A short time subsequent to this event, his employer asked him if he intended to continue in the business. Previous to giving a decisive answer, he inquired his opinion of its permanency. The reply was, that it would not probably continue as good as then, but, under proper management, would doubtless always be a fair business. So little did even its founders foresee the vast extension to which it was designed, and the astonishing change in politics, commerce, and the relations of states to each other, which have been the consequence. Indeed, all the cotton manufacture of England was then confined to a small district in Derbyshire, and its whole amount not greater than that done at the present day in a single village in New England.

Young Slater early manifested the bent of his mind, frequently spending his Sundays alone in making experiments in machinery; and for six months was without seeing any of his friends, though living only a mile from home. This was not from a want of filial or fraternal affection, but solely through devotion to his employment. As showing the propensity and expertness of his mind at this period, the following circumstance is related:—His master in vain endeavored to improve the "heart motion" so as to raise or enlarge the yarn in the middle, in order to contain more on the bobbin. Slater seeing through the difficulty, went to work, and the next Sunday (his only spare time) succeeded in that, which his employer, with all his ingenuity, was unable to effect. This general application on Slater's part was not without its benefits; his employers gained so much confidence in his business habits and industry, that during the last four or five years of his stay with them he was engaged as an overseer. This general oversight, with his close habits of observation, eventually proved of incalculable service.

Slater was fortunate in having for his employer a man of so much stability and integrity, who took a great deal of pains to properly mould his character and habits. He was, like all other business men, a strict economist in that which related to his profession, and would often enforce his maxims on his young protegé. As an illustration, the following anecdote is related:—When Slater was yet a boy, he passed by some loose cotton on the floor; Mr. Strutt called him back, with a request to pick it up, for it was by attending to such small things that great fortunes were accumulated; at the same time observing to his wife, by way of impress-

ing it more strongly on the mind of his favorite apprentice, that he "was afraid that Samuel would never be rich."

Slater faithfully served his indenture with Mr. Strutt. This accomplishment of his *full* time was characteristic with him, and was praiseworthy and beneficial, as it laid the foundation of his adaptation to business, and finally to its perfect knowledge.

He early turned his attention to the United States, as affording a vast field for enterprise in his department. This originated partially from an apprehension that the business would be ruined by competition in his native country, and, with this idea, he would seek every means to gain information. The motives which finally induced him to leave, were the various rumors which reached Derbyshire of the anxiety of the different state governments here to encourage manufactures. Slater was more strongly confirmed in this determination on observing a newspaper account of a liberal bounty granted by the legislature of Pennsylvania to a person who had imperfectly succeeded in constructing a carding machine, to make rolls for jennies; and the knowledge, too, that a society had been authorized by the same legislature for the promotion of manufactures.

Having made due preparation, he secretly, and without divulging his plans to even a single individual, bid farewell to the home of his childhood. What were his feelings in gazing, for the last time, on the countenances of his mother, brothers, and sisters, only those who have been in similar circumstances can imagine; his young heart was full, but a youthful ambition fired his soul, and enabled him to overcome his emotions. While waiting in London until the vessel was ready, he wrote to his friends, informing them of his plans, but, for obvious reasons, did not put the letter into the office until ready to embark.

The ship being ready, Mr. Slater embarked, Sept. 1st, 1789, being at that time only a few months over twenty-one years of age. He was aware of the danger incurred in leaving England as a *machinist*, and therefore took no drawings of any sort, trusting solely to the powers of his memory to enable him to construct the most complicated of machinery. Indeed, he had no writing with him excepting his indenture, which was his sole introduction to the western world. After a tedious passage of sixty-six days, he arrived in New York. Here he obtained a temporary employment, until something permanent should arise.

Previous to Slater's arrival in America, every attempt to spin cotton warp or twist, or any other yarn, by water power, had totally failed, and every effort to import the patent machinery of England had proved abortive. Much interest had been excited in

Philadelphia, New York, Beverly, Massachusetts, and Providence but it was found impossible to compete with the superior machinery of Derbyshire * Distrust and despondency had affected the

* At a meeting held in Boston a few years since, on the subject of opening a railroad to Albany, the infant difficulties of our manufactures were thus adverted to by Mr. Hallet:—

"We talk now of the future, in regard to railways, with doubt, as of an experiment yet to be tested, and many look upon the calculations of the sanguine as mere speculating dreams. Here is a new avenue about to be opened to the development of resources, and yet men hesitate to go forward. Let us test what we can reasonably anticipate in this, by what we know has happened, in the development of resources once deemed quite as visionary, through another medium of industry and enterprise—domestic manufactures. There is not an adult among us who cannot remember the time when it was a source of mortification to be dressed in homespun. Now, our own fabrics are among the best and richest stuffs of every day consumption, and the products of our looms are preferred even in foreign countries. Forty years ago, who would have dared to conjure up the visions of such manufacturing cities as Lowell, and Fall River, your Ware, Waltham, and the hundreds of flourishing villages which now constitute the most prosperous communities in this commonwealth? How small and feeble was the beginning of all this! In 1787, the first cotton mill in this state was got up in Beverly, by John Cabot and others, and in three years it was nearly given up, in consequence of the difficulties which the first beginning of the development of the vast resources of domestic industry, in our state, had to encounter. I hold in my hand," said Mr. Hallet, "a document of uncommon interest, on this subject, found in the files of the Massachusetts senate; which will show the early struggles of domestic manufactures, and the doubts entertained of their success, more forcibly than any fact that can be stated. It is the petition of the proprietors of the little Beverly cotton mill, in 1790, for aid from the legislature to save them from being compelled to abandon the enterprise altogether. This petition was referred to the committee of both houses for the encouragement of arts, agriculture, and manufactures, (of which Nathaniel Gorham was chairman;) and with all the lights which that intelligent committee then had on this subject, destined to become one of the greatest means of developing resources ever opened to national prosperity, they cautiously reported that 'from the best information we can obtain, we are of opinion that the said manufactory is of great public utility. But owing to the great expenses incurred in providing machines, and other incidents usually attending a new business, the said manufactory is upon the decline, and unless some public assistance can be afforded, is in danger of failing. Your committee therefore report, as their opinion, that the petitioners have a grant of one thousand pounds, to be raised in a lottery:' on condition that they give bonds that the money be actually appropriated in such a way as will most effectually promote the 'manufacturing' of cotton piece goods in this commonwealth. . . . . Where now is the little Beverly cotton mill? And what has been the mighty development of resources in domestic industry in forty-five years, since the date of that petition, when the wisest men among us had got no farther than to a belief that the said manufactory was of great public utility! Is there any vision of the great public utility of railways," said Mr. Hallet, "which can go beyond what now is, and what will be in forty years, that can exceed in contrast what we know once was and now is, in the development of resources by the investment of capital and industry in domestic manufactures? The petitioners for the little Beverly cotton mill were doubtless deemed to be absurdly extravagant, when they hinted that the manufacture of cottons would one day not only afford a supply for domestic consumption, but a staple for exportation. But what do we now see? Our domestic fabrics find a market in every clime, and vessels, lying at your wharves, are receiving these goods to export to Calcutta.

"The world is beginning to understand the true uses of wealth, to develop

strongest minds, disappointment and repeated loss of property had entirely disheartened these pioneers in the production of homespun cloth. To the subject of this memoir belongs the honor of having solely, by his own personal knowledge and skill, constructed and put in motion the whole series of Arkwright's patents, and in such perfect operation, as to produce as good yarn and cotton cloth of various descriptions as the English.

In the course of Slater's inquiries for the most eligible place as the scene of his first essay in America, he was informed that attempts had lately been made in Providence and its vicinity, under the auspices of Moses Brown, who was in want of a manager in spinning. He immediately addressed a letter to Mr. Brown, and received in reply a very urgent request to render his services. In this letter he offered Slater, if he could work the machinery they had on hand, all the profits of the business, and held out the promise of the credit, as well as the advantages of perfecting the first water mill in America.

Arrangements were entered into between Almy, Brown, and Slater, to commence cotton spinning at Pawtucket.

the resources of the country; and it is in great enterprises, which benefit the public more than those immediately concerned in them, that we have a practical demonstration of the doctrine of the greatest good of the greatest number. Much is said, and more feared, about the divisions of the rich and the poor. But in truth, in our happy institutions, we need have no poor, forming a distinct class among the citizens. Where is your populace, your rabble? is an inquiry which has often puzzled the foreigner who has passed through our streets when thronged by a multitude. We have no populace—no rabble, but free and independent citizens. What has made them so? The development of our resources. What has stopped the tide of emigration that once threatened to depopulate New England? The development of our resources. Go on developing these resources, and there need be no fear of setting the poor against the rich, for there will be no poor to set against them. All will be rich, for they will have enough; and no man is in reality any richer for possessing what he cannot use. When men of capital are found hoarding it, holding it back from enterprises, and cautious of doing any thing to develop the resources of a community, there is then just cause to fear the operation of unequal and injurious distinctions. Take from industry and enterprise the means of acquiring wealth, cut off commerce, manufactures, canals, and railways, and you will lay the surest foundation possible for the despotism of one class over another. But open all these great resources to all—extend your facilities of intercourse throughout the country, and you cannot repress the energies of men; you cannot keep them poor long enough to mark them as a class. Your gradations in society will be stepped over, forward and backward, so often, that no distinct line can be kept up. This is the vast moral power, which is exerted on society by the investment of capital for public benefit, without unjust privileges; in great projects. Here are the true uses of wealth, in a government like ours, and this great specific lies at the bottom of the philosophy of our political economy. Develop the resources of the country—place the means of wealth within the reach of industry, and you produce the happy medium in society. All will then move forward evenly, as on the level of a railroad, with occasional inclined planes and elevations, but none that can stop the powerful locomotives which impel forward every New Englander—*enterprise* and *moral energy*."

A few days subsequent to his arrival in Providence, Mr. Brown took him to view the machinery in a mill which he had erected at Pawtucket. On examination, Mr. Slater felt dispirited; and shaking his head, observed, "these will not do—they are good for nothing in their present condition, nor can they be made to answer." After various disappointments, it was proposed that he should erect the series of machines called the Arkwright patents. This he promised to perform, provided he was furnished with a man to work on wood, who should be under bonds not to steal the patterns, or disclose the nature of the works. "Under my proposals," says he, "if I do not make as good yarn as they do in England, I will have nothing for my services, but will throw the whole of what I have attempted over the bridge."

On the 21st of December, 1790, Mr. Slater started three cards, drawing, roving, and seventy-two spindles, which were operated by an old fulling-mill water-wheel in a clothier's shop at the western end of Pawtucket bridge. In this place they continued the spinning until the subsequent erection of the "old mill," so called. The difficulties under which these first measures towards the establishment of the business were pursued, can hardly be conceived at the present day, even by a practical machinist or manufacturer. The basin of the Narragansett bay, and the small, but invaluable streams that fall into it on every side, did not, at that early day, form, as they now do, a continuous hive of mechanical industry, enterprise, and skill, where every sort of material, and even the most minute subdivision of handicraft ingenuity, can be procured at will. There were no magazines or workmen. With the exception of scythes, anchors, horse-shoes, ploughs, nails, cannon, shot, and a few other articles of iron, there was no staple manufacture for exportation. The mechanism then applied in their manufacture was almost as simple as the first impulse of water or steam. Even the side motion of the card machine had not been adopted; the first hint for its use having been obtained several years after. Although Mr. Slater had full confidence in his own remembrance of every part, and ability to perfect the work, he found it next to an impossibility to get those who could make any thing like his models. But there are few difficulties that can discourage an ingenious, enterprising, and determined mind. The various materials required for the first machines were collected at much expense from different parts of the country, and young Slater's own skill and perseverance supplied the place of other mechanics.

It was now, when he flattered himself with an entire success, that an unforeseen difficulty arose. After the frames were ready

for operation, he prepared the cotton and started the cards, but it rolled *up* on the top cards instead of passing *through* the small cylinder. This was the cause of the greatest perplexity, and days were passed in the utmost anxiety as to the final result. On advising with his assistant and pointing out the defect, he perceived that the teeth of the cards were not crooked enough; as they had no good card leather, the punctures were made by hand, and consequently were too large, so that the teeth fell back from their proper place. Luckily it occurred to them to beat the teeth with a piece of grindstone; this gave them the proper crook, and, to their joy and relief, the machinery worked perfectly.

On Slater's arrival in Pawtucket, he was introduced into the worthy family of Mr. Oziel Wilkinson as a boarder. These people were Quakers, and became greatly interested in the young stranger; they have since described his conduct during the difficulty just alluded to. When leaning his head over the fire-place, they heard him utter deep sighs, and frequently observed the tears roll from his eyes. He said but little of his fears and apprehensions; but Mrs. Wilkinson, perceiving his distress, with a motherly kindness inquired, "Art thou sick, Samuel?" He then explained to them the nature of his trial, and showed the point on which he was most tender. "If," said he, "I am frustrated in my carding machine, they will think me an impostor." He was apprehensive that no suitable cards could be obtained, short of England; and from thence none were allowed to be exported.

While in this family, a tender attachment arose between himself and one of its female members, Miss Hannah Wilkinson. He was happy in fixing his affections so soon on one who loved him, and one so worthy; this was the loadstone that served to bind him to the place, when every thing else appeared dreary and discouraging. Her parents being Friends, could not consistently give consent to her marriage out of the society, and talked of sending her away some distance to school, which occasioned Mr. Slater to say, "You may send her where you please, but I will follow her to the ends of the earth." Though absorbed in perplexing business, his hours of relaxation were cheering; he spent them in telling Hannah and her sister the story of his early life, the tales of his home, of his family connections, and of his father land.

This introduction was one of the favorable circumstances that finally secured his success. Here was found a father and mother, who were kind to him as to their own son. He was not distrustful of his ability to support a family—did not wait to grow rich before marriage, but was willing to take his bride for better and

for worse; and she received the young stranger as the man of her choice, the object of her first love. This connection with Oziel Wilkinson was of great service to him, as a stranger, inexperienced in the world beyond his peculiar sphere. Besides, it is well known, that sixty years since, the contrast of character of New England men and manners, and other peculiarities, were very great between the two countries. No one knows the heart of a stranger but he who has been from home in a strange land, without an old acquaintance, without a tried friend to whom he could unbosom his anxieties—without confidence in those around him, and others without confidence towards him. Mr. Slater's own experience taught him ever to treat the numerous strangers who flocked to him for advice, assistance, or employment, with marked attention, without partiality, and without hypocrisy.

Early in 1793, Almy, Brown, and Slater built a small factory in Pawtucket, which is now called the "Old Mill," where they slowly added to their machinery as the sales of yarn increased. The disposal of the yarn in market was at first found as difficult as the first construction of the machinery for its manufacture. Such are the prejudices of mankind, and their unwillingness to break over long-established habits and opinions, that, superior as was this yarn in material and durability to that imported, people would hardly be convinced, even by actual experiment, that it was *possible* to make good cotton yarn at home. That made by these pioneers in American manufacture would sometimes be on hand in large quantities, or could be got rid of only as "truck," whilst the English made yarn was eagerly sought for at a much higher price in money. In a note found among Mr. Slater's papers, we are informed that when the first seventy-two spindles and *preparation* had been at work only twenty months, "they had several thousand pounds of yarn on hand, notwithstanding every exertion was used to weave it up and sell it." The same difficulty was experienced in the sale of yarn at intervals, until the introduction of the power loom. Slow as was the advancement of spinning until twenty years after its first establishment, it never attained the advantage of a quick remunerating staple business until the loom was placed beside the spinning frame, and propelled by the same power. The power loom, twenty or thirty years ago, did for the spinning frame what has since been done for the loom by the printery,—it furnished an immediate and ready consumption. and a market ready for its products.*

* As an evidence of the vast improvements in the manufacture and culture of cotton, it is stated, that at the time of Slater's arrival in this country, good cotton cloth *was fifty cents a yard, and never less than forty.*

It was only in 1799 that the sales of yarn became sufficiently promising to induce another company to set up the second cotton mill establishment in Rhode Island, and Messrs. Almy, Brown, and Slater were encouraged to make very considerable additions to the machinery in the "Old Mill." Their subsequent business, up to the year 1806, turned their attention to a more extended investment in spinning, and from thenceforth it was continually on the increase.

Mr. Slater was a philanthropist in its most important sense, and ever manifested an interest in the welfare of those under his charge. No sooner did he find his business collected young people and children who were destitute of the means of instruction, than he commenced establishing a Sunday school in his own house, sometimes instructing his scholars himself, but generally hiring a person to perform that duty. This was the first Sunday school in the United States; and what appears to us not a little singular, was regarded by some as an unhallowed innovation;—one young man, the son of a *clergyman*, was at first deterred from becoming a teacher, because his father considered it a *profanation* of the Sabbath!

The impulse given to industry and production by the cotton manufacture has not been confined to one branch alone, but has been felt in every kind of employment useful to the community. We need not in this place enlarge upon the close affinity and mutual dependence of these various employments; they are obvious to every mind which has acquired the habit of tracing results to their causes in the endless relations of society. As a general fact, it is undoubtedly true, that the advancement of our country in the manufactures of wool and iron, has been greatly accelerated by the cotton manufacture; and that *those* branches of industry have always been deeply affected by the temporary reverses which *this* branch has experienced.

Mr. Slater was for many years, until the time of his death, concerned in woollen and iron, as well as cotton manufactories, and his observation and sagacity never suffered him to question the identity of their interests. There was another point in which his views and sentiments, though decried by some as too liberal and disinterested in any matter of business, were truly wise and sagacious, and fully concurred in by his partners. He always maintained that legislative protection would be as beneficial to himself as to others; to those already established in business and possessing an ample capital, as those just commencing, with little or no means. This opinion, notwithstanding all the huckstering calculations and short sighted views of would-be monopolists, was certainly the

best for himself. Monopoly in this country, by any men, or set of men, subject to our laws, is unattainable, either by legislation or combination. It is, or ought to be, excluded from all the calculations of a sober and practical business mind. There was, therefore, nothing in their preoccupation of the cotton business that gave them an advantage over other domestic manufacturers, except their skill and capital. Of these advantages legislation could or would not deprive them; and with them on their side, they could extend their investments as fast, certainly with as much profit, as those who were without, or with capital only. In petitions and other means adopted by the manufacturing districts of our country, to obtain this protection, Mr. Slater was ever a prominent and efficient person.

Such are the outlines of the business life of a man, whose skill and knowledge of detail was unrivalled, in a business which, up to the time of his appearance, was unknown in this country,—whose commercial views were of the most liberal and enlightened character,—whose energy, perseverance, and untiring diligence, aided in his early efforts by the money and countenance of those who justly appreciated his merits, and confidently anticipated his eminence, have triumphed over obstacles which would have discouraged others; have given a new direction to the industry of his adopted country, and opened a new and boundless field to its enterprise. It has rarely fallen to the lot of any single individual to be made an instrument, under Providence, of so much and such widely diffused benefit to his fellow men, as this man has conferred upon them, without any pretension to high-wrought philanthropy in the ordinary, unostentatious pursuit of that profession to which he had been educated.

Yet, unpretending as he was, and noiseless in that sublimated charity which is now so fashionable and predominant, his sympathy for the distressed, and his kindness and good-will for all, were ever warm, active, practical sentiments; based upon steadfast principles, and aiming at the greatest attainable measure of good. In the relief of immediate and pressing want, he was prompt and liberal; in the measures which he adopted for its prevention in future, he evinced paternal feeling and judicious forecast. Employment and liberal pay to the able bodied promoted regularity and cheerfulness in the house, and drove the wolf from its door. "Direct charity," he has been heard to say, "places its recipient under a sense of obligation which trenches upon that independent spirit that all should maintain. It breaks his pride, and he soon learns to beg and eat the bread of idleness without a blush. But employ and pay him, and he receives and enjoys with an honest pride, that

which he knows he has earned, and could have received for the same amount of labor from any other employer." It would be well for all communities if such views on the subject of pauperism, were generally adopted and carried into practice.

It is hardly necessary to state of one who has done so much business, and with so great success, that his business habits and morals were of the highest character. The punctual performance of every engagement, in its *true spirit* and meaning, was, with him, a point of honor, from which no consideration of temporary or prospective advantage would induce him to depart,—from which no sacrifice of money or feeling was sufficient to deter him. There was a method and arrangement in his transactions, by which every thing was duly and at the proper time attended to. Nothing was hurried from its proper place, nothing postponed beyond its proper time. It was thus that transactions, the most varied, intricate, and extensive, deeply affecting the interests of three adjoining states, and extending their influence to thousands of individuals, proceeded from their first inception to their final consummation, with an order, a regularity and certainty, truly admirable and instructive. The master's mind was equally present and apparent in every thing, from the imposing mass of the total to the most minute particular of its component parts.

Mr. Slater's private and domestic character was without a blemish. He was twice married, and had four children, all sons, by his first wife, and at his death left a pious and amiable widow, formerly Mrs. Parkinson, of Philadelphia, with an ample dowry, to receive from his family that protection and affection which her motherly attention to them has so well deserved. He was a sincere and practical Christian, and died, April 21st, 1835, in the cheering hopes and consolations which Christianity alone imparts.

We conclude this memoir with the following tribute to his memory, which is in substance the remarks of Mr. Tristam Burgess, in his address before the Rhode Island Agricultural Society:—"Forty years ago there was not a spindle wrought by water on this side the Atlantic. Since then, how immense the capital by which spinning and weaving machinery are moved! How many, how great, how various, the improvements! The farmers of Flanders erected a statue in honor of him who introduced into their country the culture of the potato. What shall the people of New England do for him who first brought us the knowledge of manufacturing cloth, by machinery moved by water? In England, he would in life be ornamented with a peerage, in death, lamented by a monument in Westminster Abbey. The name of *Slater* will be remembered as one of our greatest public benefactors. Let not the rich

in his adopted country, envy the products of his labor—his extensive opulence—his fair and elevated character. Let the poor rise up and call him blessed; for he has introduced a species of industry into our country, which furnishes them with labor, food, clothing, and habitation."

ELI WHITNEY,

THE INVENTOR OF THE COTTON GIN.

Birth.—Anecdotes of his youth.—Manufactures nails.—Teaches school.—By his own exertions prepares for college.—Anecdotes of his college life.—Graduates. —Goes to Georgia as a teacher.—Disappointment.—Becomes an inmate in the family of Gen. Greene.—Ingenuity.—Low state of the cotton culture.—An introduction.—Old method of separating the cotton from the seed.—Invents the cotton gin.—Forms a co-partnership with Mr. Phineas Miller to manufacture gins.—*Note*, Description.—The first machine stolen.—Commencement of encroachments.—Disastrous fire.—A trial.—Its unfortunate issue.—Gloomy prospects.—South Carolina purchases the patent right for that state.—Enters into a similar engagement with North Carolina and Tennessee.—South Carolina and Tennessee annul their contracts.—Increasing encroachments.—South Carolina Legislature, of 1804, rescind the act of annulment.—Death of Mr. Miller.—Celebrated decision of Judge Johnson.—Lawsuits.—Commences manufacturing arms for government.—Difficulties to be surmounted.—Description of the system.—Rejection of the memorial to congress for a renewal of the patent right on the cotton gin.—Marriage.—Death.—A comparison.—Character.

To the efforts of Whitney, our country is indebted for the value of her great staple. While the invention of the cotton gin has been the chief source of the prosperity of the southern planter, the northern manufacturer comes in for a large share of the benefit derived from the most important offspring of American ingenuity.

Eli Whitney* was born in Westborough, Worcester county, Massachusetts, December 8th, 1765. His parents belonged to that respectable class in society, who, by the labors of husbandry, manage, by uniform industry, to provide well for a rising family,—a class from whom have arisen most of those who, in New England, have attained to high eminence and usefulness.

The following incident, though trivial in itself, will serve to show at how early a period certain qualities, of strong feeling tempered by that discretion for which Mr. Whitney afterwards became distinguished, began to display themselves. When he was six or seven years old, he had overheard the kitchen maid, in a fit of passion, calling his mother, who was in a delicate state of health, hard names, at which he expressed great displeasure to his sister. "She

* Condensed from the able memoir by Professor Olmsted, published in the twenty-first volume of Silliman's Journal.

thought," said he, "that I was not big enough to know any thing; but I can tell her, I am too big to hear her talk so about my mother. I think she ought to have a flogging, and if I knew how to bring it about, she should have one." His sister advised him to tell their father. "No," he replied, "that will not do; it will hurt his feelings and mother's too; and besides, its likely the girl will say she never said so, and that would make a quarrel. It is best to say nothing about it."

Indications of his mechanical genius were likewise developed at a very early age. Of his early passion for such employments, his sister gives the following account. "Our father had a workshop, and sometimes made wheels, of different kinds, and chairs. He had a variety of tools, and a lathe for turning chair posts. This gave my brother an opportunity of learning the use of tools when very young. He lost no time, but as soon as he could handle tools he was always making something in the shop, and seemed not to like working on the farm. On a time, after the death of our mother, when our father had been absent from home two or three days, on his return, he inquired of the housekeeper, what the boys had been doing. She told him what B. and J. had been about. 'But what has *Eli* been doing?' said he. She replied, he had been making a fiddle. '*Ah!* (added he despondingly) *I fear Eli will have to take his portion in fiddles.*' He was at this time about twelve years old. His sister adds, that this fiddle was finished throughout, like a common violin, and made tolerable good music. It was examined by many persons, and all pronounced it to be a remarkable piece of work for such a boy to perform. From this time he was employed to repair violins, and had many nice jobs, which were always executed to the entire satisfaction, and often to the astonishment of his customers. His father's watch being the greatest piece of mechanism that had yet presented itself to his observation, he was extremely desirous of examining its interior construction, but was not permitted to do so. One Sunday morning, observing that his father was going to meeting, and would leave at home the wonderful little machine, he immediately feigned illness as an apology for not going to church. As soon as the family were out of sight, he flew to the room where the watch hung, and taking it down, he was so delighted with its motions, that he took it to pieces before he thought of the consequences of his rash deed; for his father was a stern parent, and punishment would have been the reward of his idle curiosity, had the mischief been detected. He, however, put the work all so neatly together, that his father never discovered his audacity until he himself told him, many years afterwards."

Whitney lost his mother at an early age, and when he was thirteen years old, his father married a second time. His step-mother, among her articles of furniture, had a handsome set of table knives, that she valued very highly; which our young mechanic observing, said to her, "I could make as good ones if I had tools, and I could make the necessary tools if I had a few common tools to make them with." His step-mother thought he was deriding her, and was much displeased; but it so happened, not long afterwards, that one of the knives got broken, and he made one exactly like it in every respect, except the stamp on the blade. This he would likewise have executed, had not the tools required been too expensive for his slender resources.

When Whitney was fifteen or sixteen years of age, he suggested to his father an enterprise, which was an earnest of the similar undertakings in which he engaged on a far greater scale in later life. This being the time of the revolutionary war, nails were in great demand, and bore a high price. At that period, nails were made chiefly by hand, with little aid from machinery. Young Whitney proposed to his father to procure him a few tools, and to permit him to set up the manufacture. His father consented, and he went steadily to work, and suffered nothing to divert him from his task until his day's work was completed. By extraordinary diligence, he gained time to make tools for his own use, and to put in knife blades, and to perform many other curious little jobs, which exceeded the skill of the country artisans. At this laborious occupation the enterprising boy wrought alone, with great success, and with much profit to his father, for two winters, pursuing the ordinary labors of the farm during the summers. At this time he devised a plan for enlarging his business and increasing his profits. He whispered his scheme to his sister, with strong injunctions of secrecy; and requesting leave of his father to go to a neighboring town, without specifying his object, he set out on horseback in quest of a fellow laborer. Not finding one so easily as he had anticipated, he proceeded from town to town, with a perseverance which was always a strong trait of his character, until at the distance of forty miles from home, he found such a workman as he desired. He also made his journey subservient to his improvement in mechanical skill, for he called at every workshop on his way, and gleaned all the information he could respecting the mechanic arts.

At the close of the war, the business of making nails was no longer profitable; but a fashion prevailing among the ladies of fastening on their bonnets with long pins, he contrived to make those with such skill and dexterity, that he nearly monopolized the

business, although he devoted to it only such seasons of leisure as he could redeem from the occupations of the farm, to which he now principally betook himself. He added to this article the manufacture of walking canes, which he made with peculiar neatness.

We are informed that he manifested an aptness for mathematical calculations, and that when quite young was considered not only remarkable for his ingenuity, but for general information.

From the age of nineteen, young Whitney conceived the idea of obtaining a liberal education; and partly by the avails of his mechanical industry, and partly by teaching a village school, was enabled so far to surmount the difficulties thrown in his way, as to prepare himself for the freshman class in Yale college, which he entered in 1789. While a schoolmaster, the mechanic would often usurp the place of the teacher; and the mind, too aspiring for such a sphere, was wandering off in pursuit of "*perpetual motion.*" At college his mechanical propensity frequently showed itself. He successfully undertook on one occasion the repairing of some of the philosophical apparatus. On another, a carpenter being at work at the house where Whitney boarded, he solicited the permission to use his tools. The carpenter being unwilling to trust him, only granted the request on the gentleman of the house promising to be responsible for the damages; but no sooner had Whitney commenced operations, than the man, astonished, exclaimed, "There was one good mechanic spoiled when you went to college." Soon after taking his degree in the autumn of 1792, Mr. Whitney engaged with a Mr. B., of Georgia, to reside in his family as a private teacher. On his arrival he was informed that Mr. B. had employed another person, leaving him without resources or friends, save in the family of Gen. Greene, of Mulberry Grove, near Savannah, with whom he had formed an accidental acquaintance. These benevolent people, however, deeply interested themselves in his case, and hospitably offered him the privilege of making his home at their house, where he commenced the study of law.

While residing there, Mrs. Greene was employed in embroidery which is worked on a kind of frame, called a *tambour*. She complained of its bad construction, and observed it tore the delicate threads of her work. Mr. Whitney, eager for an opportunity to oblige his hostess, set himself to work and speedily produced a tambour frame on a plan entirely new, with which he presented her. Mrs. Greene and her family were much delighted with it, and considered it a wonderful piece of ingenuity.

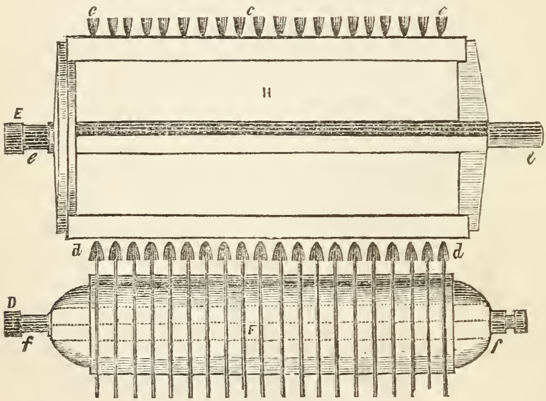
Not long after the family were visited by a party of gentlemen, consisting principally of officers who had served under the general,

in the revolutionary army. The conversation turning upon the state of agriculture, it was regretted that there was no means of cleaning the seed from the green seed cotton, which might otherwise be profitably raised on lands unsuitable for rice. But, until ingenuity could devise some machine which would grealy facilitate the process of cleaning, it *was vain to think of raising cotton for market. Separating one pound of the clean staple from the seed was a day's work* for a woman; but the time usually devoted to the picking of the cotton was the evening, after the labor of the field was over. Then the slaves, men, women, and children, were collected in circles with one, whose duty it was to rouse the dozing and quicken the indolent. While the company were engaged in this conversation, "Gentlemen," said Mrs. Greene, "apply to my young friend, Mr. Whitney, he can make any thing," at the same time showing them the tambour frame and several other articles which he had made. She introduced the gentlemen to Whitney himself, extolling his genius, and commending him to their notice and friendship. He modestly disclaimed all pretensions to mechanical genius, and on their naming the object, replied that he had never seen cotton seed in his life. Mrs. G. said to one of the gentlemen, "I have accomplished my aim, Mr. Whitney is a very deserving young man, and to bring him into notice was my object. The interest which our friends now feel for him, will, I hope, lead to his getting some employment to enable him to prosecute the study of the law."

But no one foresaw the change that this interview was to make in the plan of his life. He immediately began upon the task of inventing and constructing that machine, on which his future fame depended. Mr. Miller, to whom he communicated his design, warmly encouraged him in it, and gave him a room in his house, wherein to carry on his operations. Here he set himself to work, with the disadvantage of being obliged to manufacture his tools and draw his own wire, an article then not to be found in Savannah. Mr. Phineas Miller and Mrs. Greene were the only persons who knew any thing of his occupation. The many hours he spent in his mysterious pursuits, afforded matter of great curiosity, and often of raillery, to the younger members of the family. Near the close of the winter, the machine was so nearly completed as to leave no doubt of his success.

The individual who contributed most to incite him to persevere in the undertaking, was Mr. Miller, who was a native of Connecticut, and a graduate of Yale college. Like Mr. Whitney, soon after he had completed his education, he came to Georgia as a private teacher, in the family of Gen. Greene, and after the decease

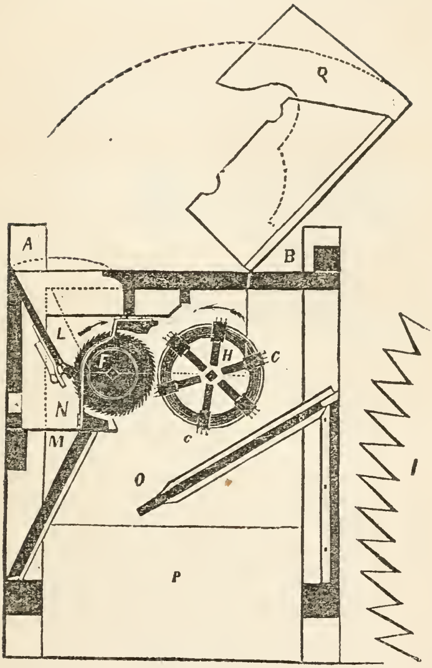
of the general, he became the husband of Mrs. Greene. He had qualified himself for the profession of law, and was a gentleman of cultivated mind and superior talents; but he was of an ardent temperament, and therefore well fitted to enter with zeal into the views which the genius of his friend had laid open to him. He had also considerable funds at command, and proposed to Mr. Whitney to become the joint adventurer, and to be at the whole expense of maturing the invention* until it should be patented. If the machine



PLAN OF THE SAW AND BRUSH CYLINDERS.

* *Description of Whitney's Cotton Gin.*—The principal parts are two cylinders of different diameters, (see F H, section and plan,) mounted in a strong wooden frame, A, which are turned by means either of a handle or a pulley and belt, acting upon the axis of a fly wheel, attached to the end of the shaft, opposite to that seen in the section. Its endless band turns a large pulley on the end D of the saw cylinder F, and a smaller pulley on the end E of the brush cylinder H, (see plan,) so as to make the latter revolve with the greater rapidity. Upon the wooden cylinder F, ten inches in diameter, are mounted, three quarters of an inch apart, fifty, sixty, or even eighty, circular saws, edged as at I, (see section,) of one foot diameter, which fit very exactly into grooves cut one inch deep into the cylinder. Each saw consists of two segments of a circle, and is preferably made of hammered (not rolled) sheet iron; the teeth must be kept very sharp. Opposite to the interstices of the saws are flat bars of iron, which form a parallel grid of such a curvature, that the shoulder of the slanting saw tooth passes first, and then the point. By this means, when a tooth gets bent by the seeds, it resets itself by rubbing against the grid bars, instead of being torn off, as would happen did the apex of the saw tooth enter first. Care must be taken that the saws revolve in the middle of their respective grid intervals, for if they rubbed against the bars they would tear the cotton filaments to pieces. The hollow cylinder H, is mounted with the brushes *c c c*, the tips of whose bristles ought to touch the saw teeth, as at *d, d*, (see plan,) and thus sweep off the adhering cotton wool. The cylinder H revolves in an opposite direction to the cylinder F, as is indicated by the arrows in the section.

The seed cotton, as picked from the pods, is thrown into the hopper L, (see



COTTON GIN.

should succeed in its intended operation, the parties agreed, under legal formalities, "that the profits and advantages arising therefrom, as well as all privileges and emoluments to be derived from patenting, making, vending, and working the same, should be mutually and equally shared between them." This instrument bears date May 27, 1793, and immediately afterwards they commenced business under the firm of Miller and Whitney.

An invention so important to the agricultural interests (and, as it has proved, to every department of human industry,) could not long remain a secret. The knowledge of it soon spread through the state, and so great was the excitement on the subject, that multitudes of persons came from all quarters of the state to see the machine; but it was not deemed safe to gratify their curiosity until the patent right should be secured. But so determined were some of the populace to possess this treasure, that neither law nor justice could restrain them; they broke open the building by night, and carried off the machine. In this way the public became possessed of the invention; and before Mr. Whitney could complete his model and secure his patent, a number of machines were in successful operation, constructed with some slight deviation from the original, with the hope of evading the penalty for violating the patent right.

As soon as the copartnership of Miller and Whitney was formed, Mr. Whitney repaired to Connecticut, where, as far as possible, he was to perfect the machine, obtain a patent, and manufacture and ship for Georgia, such a number of machines as would supply the demand.

section;) the disc saws, I, in turning round, encounter the cotton filaments resting against the grid, catch them with their sharp teeth, and drag them inwards and upwards, while the striped seeds, too large to pass between the bars, fall through the bottom N of the hopper, upon the inclined board M. The size of the aperture N, is regulated at pleasure by an adjusting screw to suit the size of the particular species of seeds. The saw teeth, filled with cotton wool, after returning through the grid, meet the brushes *c c c* of the cylinder H, and deliver it up to them; the cotton is thereafter whisked down upon the sloping table O, and thence falls into the receptacle P. A cover Q (see section) encloses both the cylinders and the hopper; this cover is turned up around the hinges as shown in the section, in order to introduce the charge of seed cotton into the machine, and is then let down before setting the wheels in gear with the driving power. The axis *e e*, *f f*, of the cylinders (see plan) should be well fitted into their plummer box bearings, so as to prevent any lateral swagging, which would greatly injure their operation. The raised position of the cover is obvious in the section, the hinge being placed at B. By means of the cotton gin, one man with the aid of a water wheel possessing a two horse power, can clean *five thousand pounds* of seed cotton in a day, eighty saws being mounted upon his machine. The cleaned wool forms generally one fourth of the weight of the seed cotton, and sometimes so much as twenty-seven per cent. The ginners are usually a distinct body from the planters, and they receive for their work one-eighth, or one-tenth of the nett weight of the cleaned cotton, under an obligation to supply all the seed required by the planter.

Within three days after the conclusion of the copartnership, Mr. Whitney having set out for the north, Mr. Miller commenced his long correspondence relative to the cotton gin. The first letter announces that encroachments upon their rights had already commenced. "It will be necessary," says Mr. Miller, "to have a considerable number of gins made, to be in readiness to send out as soon as the patent is obtained, in order to satisfy the absolute demands, and make people's heads easy on the subject; *for I am informed of two other claimants for the honor of the invention of cotton gins, in addition to those we knew before.*"

At the close of this year (1793) Mr. Whitney was to return to Georgia with his cotton gins, where his partner had made arrangements for commencing business immediately after his arrival. The importunity of Mr. Miller's letters, written during the preceding period, urging him to come on, evinces how eager the Georgia planters were to enter the new field of enterprise which the genius of Whitney had laid open to them. Nor did they at first *in general* contemplate availing themselves of the invention unlawfully. But the minds of the more honorable class of planters were afterwards deluded by various artifices, set on foot by designing men, with the view of robbing Mr. Whitney of his just rights.

One of the greatest difficulties experienced by men of enterprise, at this period, was the extreme scarcity of money, which embarrassed them to such a degree as to render it almost impossible to construct machines fast enough.

In April he returned to Georgia; during his absence he was strongly importuned to return by his partner, on account of the infatuated eagerness of the Georgia planters to obtain the advantages of his machine. Large crops of cotton were planted, the profits of which were to depend, of course, entirely on the success and employment of the gin.

The *roller gin* was at first the most formidable competitor with Whitney's machine. It extricated the seed by means of rollers, crushing them between revolving cylinders, instead of disengaging them by means of teeth. The fragments of seeds which remained in the cotton rendered its execution much inferior in this respect to Whitney's gin, and it was also much slower in its operation. Great efforts were made, however, to create an impression in favor of its superiority in other respects.

But a still more formidable rival appeared early in the year 1795, under the name of the *saw gin.* It was Whitney's gin, except that the teeth were cut in circular rims of iron, instead of being made of wires, as was the case in the earlier forms of the patent gin. The idea of such teeth had early occurred to Mr. Whitney,

as he afterwards established by legal proof. But they would have been of no use except in connection with the other parts of his machine; and, therefore, this was a palpable attempt to invade the patent right, and it was principally in reference to this that the lawsuits were afterwards held.

In March, 1795, in the midst of perplexities and discouragements, Mr. Whitney went to New York on business, where he was detained three weeks by fever. As soon as he was able, he went by packet to New Haven, where, on landing, he was informed, that on the preceding day, *his shop, with all his machines and papers, had been consumed by fire!* Thus was he suddenly reduced to bankruptcy, being in debt four thousand dollars, without any means of payment. His mind, however, was not one to sink under such trials as even this; he was, on the contrary, incited to more vigorous effort. Similar was the spirit manifested by Mr. Miller. The following extract of a letter of his to Mr. Whitney may be a useful lesson to young men who feel themselves overwhelmed with misfortunes:—

"I think that we ought to meet such events with equanimity. We have been pursuing a valuable object by honorable means; and I trust that all our measures have been such as reason and virtue must justify. It has pleased Providence to postpone the attainment of this object. In the midst of the reflections which your story has suggested, and with feelings keenly awake to the heavy, the extensive injury we have sustained, I feel a secret joy and satisfaction, that you possess a mind in this respect similar to my own—that you are not disheartened—that you do not relinquish the pursuit—and that you will persevere, and endeavor, at all events, to attain the main object. This is exactly consonant to my own determinations. I will devote all my time, all my thoughts, all my exertions, and all the money I can earn or borrow, to encompass and complete the business we have undertaken; and if fortune should, by any future disaster, deny us the boon we ask, we will at least deserve it. It shall never be said that we have lost an object which a little perseverance could have attained. I think, indeed, it will be very extraordinary, if two young men in the prime of life, with some share of ingenuity, with a little knowledge of the world, a great deal of industry, and a considerable command of property, should not be able to sustain such a stroke of misfortune as this, heavy as it is."

After this disaster the company began to feel much straitened for want of funds. Mr. Miller expresses a confidence that they should be able to raise money *in some way or other*, though he knows not how. He recommends to Mr. Whitney to proceed

forthwith to erect a new shop, and to recommence his business, and requests him to tell the people of New Haven, who might be disposed to render them any service, that they required nothing but a little time to get their machinery in motion before they could make payment, and that the loan of money at *twelve per cent.* per annum would be as great a favor as they could ask. But, he adds, "in doing this, use great care to avoid giving an idea that we are in a *desperate situation*, to induce us to borrow money. To people who are deficient in understanding, this precaution will be extremely necessary: men of sense can easily distinguish between the prospect of large gains, and the approaches to bankruptcy." "Such is the disposition of man," he observes on another occasion, "that while we keep afloat, there will not be wanting those who will appear willing to assist us; but let us once be given over, and they will immediately desert us."

While misfortune was thus multiplying upon them, intelligence was received from England that the manufacturers had condemned the cotton cleaned by their machines, on the ground that *the staple was greatly injured*. This news threatened the death-blow to their hopes. At this time (1796) they had thirty gins at eight different places in Georgia, some carried by horses and oxen, and some by water. Some of these were even then standing still. The company had $10,000 dollars in real estate, suited only to the purposes of ginning cotton. The following extract of a letter, written by Mr. Whitney at this period, will serve to show the state of his mind and affairs at this period:—

"The extreme embarrassments," says he, "which have been for a long time accumulating upon me, are now become so great, that it will be impossible for me to struggle against them many days longer. It has required my utmost exertions *to exist*, without making the least progress in our business. I have labored hard against the strong current of disappointment, which has been threatening to carry us down the cataract, but I have labored with a shattered oar, and struggled in vain, unless some speedy relief is obtained. . . . . Life is but short at best, and six or seven years out of the midst of it is, to him who makes it, an immense sacrifice. My most unremitted attention has been devoted to our business; I have sacrificed to it other objects from which, before this time, I might certainly have gained twenty or thirty thousand dollars. My whole prospects have been embarked in it, with the expectation that I should, before this time, have realized something from it."

The cotton from Whitney's gins was, however, sought by merchants in preference to other kinds, and respectable manufacturers

testified in its favor; and had it not been for the extensive and shameful violations of their patent right, they might yet have succeeded, but these encroachments had become so extensive as almost to annihilate its value. The issue of the first trial they were able to obtain, is announced in the following letter from Mr. Miller, dated May 11, 1797:—

"The event of the first patent suit, after all our exertions made in such a variety of ways, has gone against us. The preposterous custom of trying civil causes of this intricacy and magnitude by a common jury, together with the imperfection of the patent law, frustrated all our views, and disappointed expectations which had become very sanguine. The tide of popular opinion was running in our favor, the judge was well disposed towards us, and many decided friends were with us, who adhered firmly to our cause and interests. The judge gave a charge to the jury pointedly in our favor; after which the defendant himself told an acquaintance of his, that he would give two thousand dollars to be free from the verdict; and yet the jury gave it against us, after a consultation of about an hour. And having made the verdict general, no appeal would lie.

"On Monday morning, when the verdict was rendered, we applied for a new trial; but the judge refused it to us, on the ground that the jury might have made up their opinion on the defect of the law, which makes an aggression consist of *making, devising, and using, or selling;* whereas we could only charge the defendant with *using.*

"Thus, after four years of assiduous labor, fatigue, and difficulty, are we again set afloat by a new and most unexpected obstacle. Our hopes of success are now removed to a period still more distant than before, while our expenses are realized beyond all controversy."

Great efforts were made to obtain trial in a second suit, at the session of the court in Savannah, in May, 1798. A great number of witnesses were collected from various parts of the country, to the distance of a hundred miles from Savannah, when, behold, no judge appeared, and, of course, no court was held. In consequence of the failure of the first suit, and so great a procrastination of the second, the encroachments on the patent right had been prodigiously multiplied, so as almost entirely to destroy the business of the patentees.

In April, 1799, Mr. Miller writes as follows:—"The prospect of making any thing by ginning in this state is at an end. Surreptitious gins are erected in every part of the country; and the jurymen at Augusta have come to an understanding among them-

selves, that they will never give a cause in our favor, let the merits of the case be as they may."

The company would now have gladly relinquished the plan of working their own machines, and confined their operations to the sale of patent rights; but few would buy a patent right which they could use with impunity without purchasing, and those few, hardly in a single instance, paid cash, but gave their notes, which they afterwards to a great extent avoided paying, either by obtaining a verdict from the juries declaring them void, or by contriving to postpone the collection until they were barred by the statute of limitations, a period of only four years. When thus barred, the agent of Miller and Whitney, who was despatched on a collecting tour through the state of Georgia, informed them, that such obstacles were thrown in his way from one or the other of the foregoing causes, he was unable to collect money enough from all these claims to bear his expenses, but was compelled to draw for nearly the whole amount of these upon his employers.

It was suggested that an application to the legislature of South Carolina to purchase the patent right for that state would be successful. Mr. Whitney accordingly repaired to Columbia, and the business was brought before the legislature soon after the opening of the session in December, 1801. An extract from a letter of Mr. Whitney to his friend Stebbins, at this time, will show the nature of the contract thus made:—

"I have been at this place a little more than two weeks, attending the legislature. They closed their session at ten o'clock last evening. A few hours previous to their adjournment, they voted to purchase, for the state of South Carolina, my patent right to the machine for cleaning cotton, at fifty thousand dollars, of which sum twenty thousand is to be paid in hand, and the remainder in three annual payments of ten thousand dollars each." He adds, "We get but a song for it in comparison with the worth of the thing; but it is securing something. It will enable Miller and Whitney to pay all their debts, and divide something between them."

In December, 1802, Mr. Whitney negotiated a sale of his patent right with the state of North Carolina. The legislature laid a tax of two shillings and sixpence upon every saw* employed in ginning cotton, to be continued for five years; and after deducting the expenses of collection, the avails were faithfully passed over to the patentee. This compensation was regarded by Mr. Whitney as more liberal than that received from any other source. About the same time, Mr. Goodrich, an agent of the company, entered

* Some of the gins had forty saws.

into a similar negotiation with the state of Tennessee. This state had by this time begun to realize the importance and usefulness of the invention. The citizens testified strongly their desire of coming into possession of its benefits. The legislature, therefore, passed a law, laying a tax of thirty-seven and a half cents per annum on every saw, for the space of four years.

Thus far prospects were growing favorable to the patentees, when the legislature of South Carolina unexpectedly annulled the contract she had made, suspended further payment of the balance then due, and sued for the refunding of what had already been paid.

When Mr. Whitney first heard of the transactions of the South Carolina legislature annulling their contract, he was at Raleigh, where he had just concluded his negotiation with the legislature of North Carolina. In a letter written to Mr. Miller at this time he remarks: "I am, for my own part, more vexed than alarmed by their extraordinary proceedings. I think it behooves us to be very cautious and circumspect in our measures, and even in our remarks with regard to it. Be cautious what you say or publish till we meet our enemies in a court of justice, when, if they have any sensibility left, we will make them very much ashamed of their childish conduct."

But that Mr. Whitney felt very keenly in regard to the severities afterwards practised towards him, is evident from the tenor of the remonstrance which he presented to the legislature. "The subscriber (says he) respectfully solicits permission to represent to the legislature of South Carolina, that he conceives himself to have been treated with unreasonable severity in the measures recently taken against him by and under their immediate direction. He holds that, to be seized and dragged to prison without being allowed to be heard in answer to the charge alleged against him, and indeed without the exhibition of any specific charge, is a direct violation of the common right of every citizen of a free government; that the power, in this case, is all on one side; that whatever may be the issue of the process now instituted against him, he must, in any case, be subjected to great expense and extreme hardships; and that he considers the tribunal before which he is holden to appear, to be wholly incompetent to decide, definitively, existing disputes between the state and Miller and Whitney.

"The subscriber avers that he has manifested no other than a disposition to fulfil all the stipulations, entered into with the state of South Carolina, with punctuality and good faith; and he begs leave to observe farther, that to have industriously, laboriously, and exclusively, devoted many years of the prime of his life to the invention and the improvement of a machine, from which the

citizens of South Carolina have already realized immense profits, —which is worth to them millions, and from which their posterity, to the latest generations, must continue to derive the most important benefits, and in return to be treated as a felon, a swindler, and a villain, has stung him to the very soul. And when he considers that this cruel persecution is inflicted by the very persons who are enjoying these great benefits, and expressly for the purpose of preventing his ever deriving the least advantage from his own labors, the acuteness of his feelings is altogether inexpressible."

Doubts, it seems, had arisen in the public mind as to the validity of the patent, and the patentees were supposed to have failed in the fulfilment of a part of the contract. Great exertions had been made in Georgia, where, it will be remembered, hostilities were first declared against him, to show that his title to the invention was unsound, and that *somebody* in Switzerland had conceived of it before him, and that the improved form of the machine, with saws instead of wire teeth, did not come within the patent, having been introduced by one Hodgin Holmes.

The popular voice, stimulated by the most sordid motives, was now raised against him throughout all the cotton growing states. The state of Tennessee followed the example of South Carolina, in annulling the contract made with him; and the attempt was made in North Carolina, but a committee of the legislature, to whom it was referred, reported in his favor, declaring " that the contract ought to be fulfilled with punctuality and good faith," which resolution was adopted by both houses. There were also high-minded men in South Carolina who were indignant at the dishonorable measures adopted by their legislature of 1803; and their sentiments had impressed the community so favorably with regard to Mr. Whitney, that at the session of 1804, the legislature not only rescinded what the previous one had done, but signified their respect for Mr. Whitney by marked commendations. Nor ought it to be forgotten that there were in Georgia, too, those who viewed with scorn and indignation the base attempts of demagogues to defraud him. The proceedings against Mr. Whitney were predicated upon impositions practised upon the public.

At this time, a new and unexpected responsibility devolved on Mr. Whitney, in consequence of the death of his partner, Mr. Miller, who died on the 7th of December, 1803. Mr. Miller had, in the early stages of the enterprise, indulged very high hopes of a sudden fortune; but perpetual disappointments appear to have attended him throughout the remainder of his life. The history of them, as detailed in his voluminous correspondence, affords an instructive exemplification of the anxiety, toil, and uncertainty

that frequently accompany too eager a pursuit of wealth, and the pain and disappointments that follow in the train of expectations too highly elated. If Mr. Miller anticipated a great bargain from an approaching auction of cotton, some sly adventurer was sure to step in before him, and bid it out of his hands. If he looked to his extensive rice crops, cultivated on the estate of General Greene, as the means of raising money to extricate himself from the numerous embarrassments into which he had fallen, a severe drought came on and shrivelled the crop, or floods of rain suddenly destroyed it. The markets unexpectedly changed at the very moment of selling, and always to his disadvantage. Heavy rains likewise destroyed the cotton crops on which he had counted for thousands; and more than all, wicked and dishonest men contrived to cheat him of his just rights, and thus his airy hopes were often frustrated, until at length he was beguiled into inextricable difficulties; and in the midst of all, and on the dawn of a brighter day, death stepped in and dissolved the pageant that had so long been dancing before his eyes.

Mr. Whitney was now left alone, to contend singly against those difficulties which had for a series of years almost broken down the spirits of both the partners. The light, moreover, which seemed to be rising upon them from the favorable occurrences of the preceding year, proved but the twilight of prosperity, and a darker night seemed about to supervene.

But the favorable issue of the affairs of Mr. Whitney, in South Carolina, during the subsequent year, and the generous receipts that he obtained from the avails of his contracts with North Carolina, relieved him from the embarrassments under which he had so long groaned, and made him in some degree independent. Still, no small portion of the funds thus collected in North and South Carolina was expended in carrying on the fruitless, endless lawsuits in Georgia.

In the United States court, held in Georgia in December, 1807 Mr. Whitney obtained a most important decision, in a suit brought against a trespasser of the name of Fort. It was on this trial that Judge Johnson gave his celebrated decision. It was in the following words:—

"*Whitney*, survivor of
Miller & Whitney,
vs.
Arthur Fort. } In equity.

"The complainants, in this case, are proprietors of the machine called the saw gin: the use of which is to detach the short staple cotton from its seed.

"The defendant, in violation of their patent right, has constructed, and continues to use this machine; and the object of this suit is to obtain a perpetual injunction to prevent a continuance of this infraction of complainant's right.

"Defendant admits most of the facts in the bill set forth, but contends that the complainants are not entitled to the benefits of the act of congress on this subject, because—

1st. The invention is not original.

2d. Is not useful.

3d. That the machine which he uses is materially different from their invention, in the application of an improvement, the invention of another person.

"The court will proceed to make a few remarks upon the several points as they have been presented to their view: whether the defendant was now at liberty to set up this defence whilst the patent right of complainants remains unrepealed, has not been made a question, and they will therefore not consider it.

"To support the originality of the invention, the complainants have produced a variety of depositions of witnesses, examined under commission, whose examination expressly proves the origin, progress, and completion of the machine by Whitney, one of the copartners. Persons who were made privy to his first discovery, testify to the several experiments which he made in their presence before he ventured to expose his invention to the scrutiny of the public eye. But it is not necessary to resort to such testimony to maintain this point. The jealousy of the artist to maintain that reputation which his ingenuity has justly acquired, has urged him to unnecessary pains on this subject. There are circumstances in the knowledge of all mankind which prove the originality of this invention more satisfactorily to the mind than the direct testimony of a host of witnesses. The cotton plant furnished clothing to mankind before the age of Herodotus. The *green seed* is a species much more productive than the *black*, and by nature adapted to a much greater variety of climate; but by reason of the strong adherence of the fibre to the seed, without the aid of some more powerful machine for separating it than any formerly known among us, *the cultivation of it would never have been made an object.* The machine of which Mr. Whitney claims the invention so facilitates the preparation of this species for use, that the cultivation of it has suddenly become an object of infinitely greater national importance than that of the other species ever can be. Is it, then, to be imagined, that if this machine had been before discovered, the use of it would ever have been lost, or could have been confined to any tract or country left unexplored by commer-

cial enterprise? But it is unnecessary to remark further upon this subject. A number of years have elapsed since Mr. Whitney took out his patent, and no one has produced or pretended to prove the existence of a machine of similar construction or use.

"2d. With regard to the utility of this discovery, the court would deem it a waste of time to dwell long upon this topic. Is there a man who hears us who has not experienced its utility? the whole interior of the southern states was languishing, and its inhabitants emigrating for want of some object to engage their attention and employ their industry, when the invention of this machine at once opened views to them which set the whole country in active motion. From childhood to age it has presented to us a lucrative employment. Individuals who were depressed with poverty and sunk in idleness, have suddenly risen to wealth and respectability. *Our debts have been paid off; our capitals have increased, and our lands trebled themselves in value. We cannot express the weight of the obligation which the country owes to this invention.* The extent of it cannot now be seen. Some faint presentiment may be formed from the reflection that cotton is rapidly supplanting wool, flax, silk, and even furs in manufactures, and may one day profitably supply the use of specie in our East India trade. Our sister states, also, participate in the benefits of this invention; for, besides affording the raw material for their manufacturers, the bulkiness and quantity of the article afford a valuable employment for their shipping.

"3d. The third and last ground taken by defendant appears to be that on which he mostly relies. In the specification, the teeth made use of are of strong wire inserted into the cylinder. A Mr. Holmes has cut teeth in plates of iron, and passed them over the cylinder. This is certainly a meritorious improvement in the mechanical process of constructing this machine. But at last what does it amount to, except a more convenient mode of making the same thing; every characteristic of Mr. Whitney's machine is preserved. The cylinder, the iron tooth, the rotary motion of the tooth, the breast work and brush, and all the merit that this discovery can assume, is that of a more expeditious mode of attaching the tooth to the cylinder. After being attached, in operation and effect they are entirely the same. Mr. Whitney may not be at liberty to use Mr. Holmes's iron plate; but certainly Mr. Holmes's improvement does not destroy Mr. Whitney's patent right. Let the decree for a perpetual injunction be entered."

This favorable decision, however, did not put a final stop to aggression. At the next session of the United States court, two other actions were brought, and verdicts for damages gained of

two thousand dollars in one case, and one thousand and five hundred dollars in the other.

The influence of these decisions, however, availed Mr. Whitney very little, for now the term of his patent right was nearly expired. More than *sixty suits* had been instituted in Georgia before a single decision on the *merits* of his claim was obtained, and at the period of this decision thirty years of his patent had expired. In prosecution of this troublesome business, Mr. Whitney had made six different journeys to Georgia, several of which were accomplished by land at a time when, compared with the present, the difficulties of such journeys were exceedingly great, and exposed him to excessive fatigues and privations, which at times seriously affected his health, and even jeopardized his life. A gentleman of much experience, who was well acquainted with Mr. Whitney's affairs in the south, and sometimes acted as his legal adviser, observes, that "in all his experience in the thorny profession of the law, he has never seen a case of such perseverance, under such persecution; nor," he adds, "do I believe that I ever knew any other man who would have met them with equal coolness and firmness, or who would finally have obtained even the partial success which he had. He always called on me in New York, on his way south, when going to attend his endless trials, and to meet the mischievous contrivances of men who seemed inexhaustible in their resources of evil. Even now, after thirty years, my head aches to recollect his narratives of new trials, fresh disappointments, and accumulated wrongs."

In 1798, Mr. Whitney became deeply impressed with the uncertainty of all his hopes founded upon the cotton gin, notwithstanding their high promise, and he began to think seriously of devoting himself to some business in which superior ingenuity, seconded by uncommon industry, qualifications which he must have been conscious of possessing in no ordinary degree, would conduct him by a slow but sure route to a competent fortune; and we have always considered it indicative of a solid judgment, and a well-balanced mind, that he did not, as is frequently the case with men of inventive genius, become so poisoned with the hopes of vast and sudden wealth, as to be disqualified for making a reasonable provision for life by the sober earnings of frugal industry.

The enterprise which he selected in accordance with these views was the manufacture of arms for the United States. He addressed a letter to the Hon. Oliver Wolcott, secretary of the treasury, by whose influence he obtained a contract for the manufacture of ten thousand stand of arms, four thousand of which were to be delivered on or before the last of September of the ensuing year, (the

contract being concluded on the 14th of January, 1798,) and the remaining six thousand within one year from that time.

The site which Mr. Whitney had purchased for his works was at the foot of the celebrated precipice called East Rock, near the city of New Haven. This spot (which is now called Whitneyville) is justly admired for the romantic beauty of its scenery. A waterfall of moderate extent afforded here the necessary power for propelling the machinery. In this pleasant retreat Mr. Whitney commenced his operations with the greatest zeal; and his great mind, and daring, persevering spirit, were abundantly manifested in this undertaking. His machinery was yet to be built, his materials to be collected, and even his workmen to be taught, and that in a business with which he was imperfectly acquainted. A severe winter retarded his operations, and the multiplied difficulties of his undertaking rendered him wholly incompetent to the fulfilment of the contract, and delivering the arms within the limited time. Only five hundred, instead of four thousand, were delivered the first year, and eight, instead of two years, were found necessary for completing the whole. Notwithstanding this, the government seems to have been altogether liberal in its dealings with him.

During the eight years Mr. Whitney was occupied in performing this engagement, he applied himself to business with the most exemplary diligence, rising every morning as soon as it was day, and at night setting every thing in order appertaining to all parts of the establishment before he retired to rest. In a letter addressed to the secretary of the treasury at this period, he says—"I find that my personal attention and oversight are more constantly and essentially necessary to every branch of the work than I apprehended. Mankind, generally, are not to be depended on, and the best workmen I can find are incapable of directing. Indeed there is no branch of the work that can proceed well, scarcely for a single hour, unless I am present." His genius, indeed, impressed itself on every part of the manufactory, extending even to the most common tools, all of which received some peculiar modification which improved them in accuracy, or efficacy, or beauty. His machinery for making the several parts of a musket was made to operate with the greatest possible degree of uniformity and precision. The object at which he aimed, and which he fully accomplished, was to make the same parts of different guns, as the locks, for example, as much like each other as the successive impressions of a copper-plate engraving. It has generally been conceded that Mr. Whitney greatly improved the art of manufacturing arms, and laid his country under permanent obligations, by augmenting her facilities for national defence. So rapid

has been the improvement in the arts and manufactures in this country, that it is difficult to conceive of the low state in which they were thirty years ago. To this advancement the genius and industry of Mr. Whitney most essentially contributed; for while he was clearing off the numerous impediments which were thrown in his way, he was at the same time performing the office of a pioneer to the succeeding generation.

In 1812 he entered into a contract to manufacture for the United States fifteen thousand stand of arms, and in the mean time he made a similar contract with the State of New York.

Several other persons made contracts with the government at about the same time, and attempted the manufacture of muskets, following, substantially, so far as they understood it, the method pursued in England.—The result of their efforts was a complete failure to manufacture muskets of the quality required, at the price agreed to be paid by the government: and in some instances they expended in the execution of their contracts, a considerable fortune in addition to the whole amount received for their work.

The low state to which the arts had been depressed in this country by the policy of England, under the colonial system, and from which they had then scarcely begun to recover, together with the high price of labor, and other causes, conspired to render it impracticable at that time even for those most competent to the undertaking, to manufacture muskets here in the English method. And doubtless Mr. Whitney would have shared the fate of his enterprising but unsuccessful competitors, had he adopted the course which they pursued; but his genius struck out for him a course entirely new.

In maturing his system he had many obstacles to combat, and a much longer time was occupied, than he had anticipated; but with his characteristic firmness he pursued his object, in the face of the obloquy and ridicule of his competitors, the evil predictions of his enemies, and the still more discouraging and disheartening misgivings, doubts, and apprehensions of his friends. His efforts were at length crowned with success, and he had the satisfaction to find, that the business which had proved so ruinous to others, was likely to prove not altogether unprofitable to himself.

Our limits do not permit us to give a minute and detailed account of this system; and we shall only glance at two or three of its more prominent features, for the purpose of illustrating its general character.

The several parts of the musket were, under this system, carried along through the various processes of manufacture, in lots of some hundreds or thousands of each. In their various stages of pro-

gress, they were made to undergo successive operations by machinery, which not only vastly abridged the labor, but at the same time so fixed and determined their form and dimensions, as to make comparatively little skill necessary in the manual operations. Such was the construction and arrangement of this machinery, that it could be worked by persons of little or no experience; and yet it performed the work with so much precision, that when, in the later stages of the process, the several parts of the musket came to be put together, they were as readily adapted to each other, as if each had been made for its respective fellow. A lot of these parts passed through the hands of several different workmen successively, (and in some cases several times returned, at intervals more or less remote, to the hands of the same workman,) each performing upon them every time some single and simple operation, by machinery or by hand, until they were completed. Thus Mr. Whitney reduced a complex business, embracing many ramifications, almost to a mere succession of simple processes, and was thereby enabled to make a division of the labor among his workmen, on a principle which was not only more extensive, but also altogether more philosophical, than that pursued in the English method. In England, the labor of making a musket was divided by making the different workmen the manufacturers of different limbs, while in Mr. Whitney's system the work was divided with reference to its nature, and several workmen performed different operations on the same limb.

It will be readily seen that under such an arrangement any person of ordinary capacity would soon acquire sufficient dexterity to perform a branch of the work. Indeed, so easy did Mr. Whitney find it to instruct new and inexperienced workmen, that he uniformly preferred to do so, rather than to attempt to combat the prejudices of those, who had learned the business under a different system.

When Mr. Whitney's mode of conducting the business was brought into successful operation, and the utility of his machinery was fully demonstrated, the clouds of prejudice which lowered over his first efforts, were soon dissipated, and he had the satisfaction of seeing not only his system, but most of his machinery, introduced into every other considerable establishment for the manufacture of arms, both public and private, in the United States.

The labors of Mr. Whitney in the manufacture of arms, have been often and fully admitted by the officers of the government, to have been of the greatest value to the public interest. In the year 1822, Mr. Calhoun, then secretary of war, admitted, in a conversation with Mr. Whitney, that the government were saving twenty-

five thousand dollars per annum at the two public armories alone, by his improvements. This admission, though it is believed to be far below the truth, is sufficient to show, that the subject of this memoir deserved well of his country in this department of her service.

It should be remarked, that the utility of Mr. Whitney's labors during the period of his life which we have now been contemplating, was not limited to the particular business in which he was engaged. Many of the inventions which he made to facilitate the manufacture of muskets, were applicable to most other manufactures of iron and steel. To many of these they were soon extended, and became the nucleus around which other inventions clustered; and at the present time some of them may be recognised in almost every considerable workshop of that description in the United States.

In the year 1812, Mr. W. made application to congress for the renewal of his patent for the cotton gin. In his memorial, he presented a history of the struggles he had been forced to encounter in defence of his right, observing that he had been unable to obtain any decision on the merits of his claim until he had been *eleven years* in the law, and *thirteen years* of his patent term had expired. He sets forth, that his invention had been a source of opulence to thousands of the citizens of the United States; that, as a labor-saving machine, it would enable one man to perform the work of a thousand men; and that it furnishes to the whole family of mankind, at a very cheap rate, the most essential article of their clothing. Hence, he humbly conceived himself entitled to a further remuneration from his country, and thought he ought to be admitted to a more liberal participation with his fellow citizens in the benefits of his invention. Although so great advantages had been already experienced, and the prospect of future benefits was so promising, still, many of those whose interest had been most promoted, and the value of whose property had been most enhanced by this invention, had obstinately persisted in refusing to make any compensation to the inventor. The very men whose wealth had been acquired by the use of this machine, and who had grown rich beyond all former example, had combined their exertions to prevent the patentee from deriving any emolument from his invention. From that state in which he had first made, and where he had first introduced his machine, and which had derived the most signal benefits from it, he had received nothing; and from no state had he received the amount of *half a cent per pound* on the cotton cleaned with his machines in one year. Estimating the value of the labor of one man at twenty cents per day, the whole amount

which had been received by him for his invention, was not equal to the value of the labor saved *in one hour*, by his machines then in use in the United States. "This invention (he proceeds) now gives to the southern section of the Union, over and above the profits which would be derived from the cultivation of any other crop, an annual emolument of at least *three millions* of dollars."* The foregoing statement does not rest on conjecture,—it is no visionary speculation,—all these advantages have been realized; the planters of the southern states have counted the cash, felt the weight of it in their pockets, and heard the exhilarating sound of its collision. Nor do the advantages stop here: this immense source of wealth is but just beginning to be opened. Cotton is a more cleanly and healthful article of cultivation than tobacco and indigo, which it has superseded, and does not so much impoverish the soil. This invention has already trebled the value of the land through a great extent of territory; and the degree to which the cultivation of cotton may be still augmented, is altogether incalculable. This species of cotton has been known in all countries where cotton has been raised, from time immemorial, but was never known as an article of commerce, until since this method of cleaning it was discovered. In short, (to quote the language of Judge Johnson,) if we should assert that the benefits of this invention exceed *one hundred millions of dollars*, we can prove the assertion by correct calculation. "It is objected that if the patentee succeeds in procuring the renewal of his patent, he will be too rich. There is no probability that the patentee, if the term of his patent were extended for twenty years, would ever obtain for his invention one half as much as many an individual will gain by the use of it. Up to the present time, the whole amount of what he has acquired from this source, (after deducting his expenses,) does not exceed one half the sum which a single individual has gained by the use of the machine in one year. It is true that considerable sums have been obtained from some of the states where the machine is used; but no small portion of these sums has been expended in prosecuting his claim in a state where nothing has been obtained, and where his machine has been used to the greatest advantage.

"Your memorialist has not been able to discover any reason why he, as well as others, is not entitled to share the benefits of his own labors. He who speculates upon the markets, and takes advantage of the necessities of others, and by these means accumulates property, is called 'a man of enterprise'—'a man of business'—he is complimented for his talents, and is protected by the

* This was in 1812: the amount of profit is at this time incomparably greater

laws. He however only gets into his possession, that which was before in the possession of another; he adds nothing to the public stock; and can he who has given thousands to others, be thought unreasonable, if he asks one in return?

"It is to be remembered, that the pursuit of wealth by means of new inventions, is a very precarious and uncertain one;—a lottery where there are many thousand blanks to one prize. Of all the various attempts at improvements, there are probably not more than one in five hundred for which a patent is taken out; and of all the patents taken out, not one in twenty has yielded a nett profit to the patentee equal to the amount of the patent fees. In cases where a useful and valuable invention is brought into operation, the reward ought to be in proportion to the hazard of the pursuit. The patent law has now been in operation more than fourteen years. Many suits for damages have been instituted against those who have infringed the right of patentees; and it is a fact, that very rarely has the patentee ever recovered. If you would hold out inducements for men of *real talents* to engage in these pursuits, your rewards must be sure and substantial. Men of this description can calculate, and will know how to appreciate, the recompense which they are to receive for their labors. If the encouragement held out be specious and delusive, the discerning will discover the fallacy, and will despise it: the weak and visionary only will be decoyed by it, and your patent office will be filled with rubbish. The number of those who succeed in bringing into operation really useful and important improvements, always has been, and always must be, very small. It is not probable that this number can ever be as great as one in a hundred thousand. It is therefore impossible that they can ever exert upon the community an undue influence. There is, on the contrary, much probability and danger that their rights will be trampled on by the many."

Notwithstanding these cogent arguments, the application was rejected by Congress. Some liberal minded and enlightened men from the cotton districts, favored the petition: but a majority of the members from that section of the Union, were warmly opposed to granting it.

In a correspondence with the late Mr. Robert Fulton, on the same subject, Mr. Whitney observes as follows:—"The difficulties with which I have had to contend have originated, principally, in the want of a disposition in mankind to do justice. My invention was new and distinct from every other: it stood alone. It was not interwoven with any thing before known; and it can seldom happen that an invention or improvement is so strongly marked, and can be so clearly and specifically identified; and I have

always believed, that I should have had no difficulty in causing my rights to be respected, if it had been less valuable, and been used only by a small portion of the community. But the use of this machine being immensely profitable to almost every planter in the cotton districts, all were interested in trespassing upon the patent right, and each kept the other in countenance. Demagogues made themselves popular my misrepresentation, and unfounded clamors, both against the right, and against the law made for its protection. Hence there arose associations and combinations to oppose both. At one time, but few men in Georgia dared to come into court, and testify to the most simple facts within their knowledge, relative to the use of the machine. In one instance, I had great difficulty in proving that the machine *had been used in Georgia, although, at the same moment, there were three separate setts of this machinery in motion, within fifty yards of the building in which the court sat, and all so near that the rattling of the wheels was distinctly heard on the steps of the court house.*"*

While, however, unsuccessfully endeavoring to secure to himself some of the avails of the immense benefits he had thus bestowed on his fellow citizens, his manufactory was gradually leading him to more affluent and liberal circumstances. In January, 1817, he married Miss Henrietta F. Edwards, the youngest daughter of the Hon. Pierpont Edwards, of the District Court for the State of Connecticut. Fortune seemed now to smile upon him, as he saw his domestic circle increase by the addition of a son and three daughters, and a prosperous and sunny close appeared to be about to terminate his stormy and vexatious day of life.

But death who comes to all, prostrated him upon a bed of pain, and after a protracted period of suffering, he breathed his last, on the 8th of January, 1825, after having labored for a long while under a formidable and tedious disease.

The strongest demonstrations of respect and regard, were manifested by the citizens of New Haven, in committing his remains to

* In one of his trials, Mr. Whitney adopted the following plan, in order to show how nugatory were the methods of evasion practised by his adversaries. They were endeavoring to have his claim to the invention set aside, on the ground, that the teeth in his machine were made of *wire*, inserted into the cylinder of wood, while in the machine of Holmes, the teeth were *cut in plates*, or iron surrounding the cylinder, forming a circular saw. Mr. Whitney, by an ingenious device, (consisting chiefly of sinking the plate below the surface of the cylinder, and suffering the teeth to project,) contrived to give to the saw teeth the appearance of *wires*, while he prepared another cylinder in which the wire teeth were made to look like *saw teeth.* The two cylinders were produced in court, and the witnesses were called on to testify which was the invention of Whitney, and which that of Holmes. They accordingly swore the saw teeth upon Whitney, and the wire teeth upon Holmes; upon which the judge declared that it was un necessary to proceed any farther, the principle of both being manifestly the same.

the earth, and the Rev. President Day pronounced over his grave the following eulogy.

"How frequent and how striking are the monitions to us, that this world is not the place of our rest!

"It is not often the case, that a man has laid his plans for the business and the enjoyment of life, with a deeper sagacity, than the friend whose remains we have now committed to the dust. He had received, as the gift of heaven, a mind of a superior order. Early habits of thinking gave to it a character of independence and originality. He was accustomed to form his decisions, not after the model of common opinion, but by his own nicely balanced judgment. His mind was enriched with the treasures which are furnished by a liberal education. He had a rare fertility of invention in the arts; an exactness of execution almost unequalled. By a single exercise of his powers, he changed the state of cultivation, and multiplied the wealth, of a large portion of our country. He set an example of system and precision in mechanical operations, which others had not even thought of attempting.

"The higher qualities of his mind, instead of unfitting him for ordinary duties, were finely tempered with taste and judgment in the business of life. His manners were formed by an extensive intercourse with the best society. He had an energy of character which carried him through difficulties too formidable for ordinary minds.

"With these advantages, he entered on the career of life. His efforts were crowned with success. An ample competency was the reward of his industry and skill. He had gained the respect of all classes of the community. His opinions were regarded with peculiar deference, by the man of science, as well as the practical artist. His large and liberal views, his knowledge of the world, the wide range of his observations, his public spirit, and his acts of beneficence, had given him a commanding influence in society. The gentleness and refinement of his manners, and the delicacy of his feelings in the social and domestic relations, had endeared him to a numerous circle of relatives and friends.

"And what were his reflections in review of the whole, in connection with the distressing scenes of the last period of life? 'All is as the flower of the grass: the wind passeth over it, and it is gone.' All on earth is transient; all in eternity is substantial and enduring. His language was, 'I am a sinner. But God is merciful. The only ground of acceptance before him, is through the great Mediator.' From this mercy, through this Mediator, is derived our solace under this heavy bereavement. On this, rest the hopes of the mourners, that they shall meet the deceased with joy, at the resurrection of the just."

The following account is given of Mr. Whitney's character,—a character not often met with in the common walks of life.

His manners were conciliatory, and his whole appearance such as to inspire universal respect. Among his particular friends, no man was more esteemed. Some of the earliest of his intimate associates were also among the latest. With one or two of the bosom friends of his youth, he kept up a correspondence by letter for thirty years, with marks of continually increasing regard. His sense of honor was high, and his feelings of resentment and indignation occasionally strong. He could, however, be cool when his opponents were heated; and, though sometimes surprised by passion, yet the unparalleled trials of patience which he had sustained did not render him petulant, nor did his strong sense of the injuries he had suffered in relation to the cotton gin, impair the natural serenity of his temper. But the most remarkable trait in the character of Mr. Whitney aside from his inventive powers, was his perseverance; and this is the more remarkable because it is so common to find men of great powers of mechanical invention deficient in this quality. This it was which led him through scenes of trial and almost unparalleled misfortune, with that calm, yet determined spirit which he so clearly manifested, and which finally led him to a period of prosperity from which he was snatched only by the hand of death.

In person Mr. Whitney was considerably above the ordinary size, of a dignified carriage, and of an open, manly, and agreeable countenance. Indeed, he seems to have won the respect of all with whom he conversed, and to have made himself friends wherever he went, by his modest, unassuming, yet agreeable manners, and by his superior skill and ingenuity.

In presenting to the public the foregoing sketch of the life of this extraordinary man, the aim has been to render the narrative useful to the enterprising mechanic and the man of business, to whom Whitney may be confidently proposed as a model. To such, it is believed, the details given respecting his various struggles and embarrassments, may afford a useful lesson, a fresh incentive to perseverance, and stronger impressions of the value of a character improved by intellectual cultivation, and adorned with all the moral virtues.

Fabrics of cotton are now so familiar to us, and so universally diffused, that we are apt to look upon them rather as original gifts of nature than as recent products of human ingenuity. The following statements however will show how exceedingly limited the cotton trade was previous to the invention of the cotton gin.

In 1784, an American vessel arrived at Liverpool, having on

board for part of her cargo, *eight bags* of cotton, which were seized by the officers of the customhouse, under the conviction that they could not be the growth of America. The following fact ascertained from old newspapers shows the limited extent of the cotton trade for the two subsequent years, viz: that the whole amount arrived at Liverpool from America was short of 120 bags. Now this article is equal in general to some millions more than one half the whole value of our exports. The annual average growth is about one million of bales, amounting to several hundred millions of pounds, of which about one fifth is used in our own manufactories.

We present, in conclusion, the following remarks of a distinguished scholar, upon this great man, occasioned by a visit to the cemetery of New Haven, which sufficiently show in what estimation he is held by those capable of appreciating his merits.

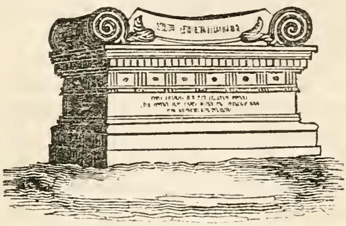
After alluding to the monument of Gen. Humphreys, who introduced the firm wooled sheep into the United States, the stranger remarks: "But Whitney's monument perpetuates the name of a still greater public benefactor. His simple name would have been epitaph enough, with the addition perhaps of 'the inventor of the cotton gin.' How few of the inscriptions in Westminster Abbey could be compared with that! Who is there that, like him, has given his country a machine—the product of his own skill—which has furnished a large part of its population, 'from childhood to age with a lucrative employment; by which their debts have been paid off; their capitals increased; *their lands trebled in value?*'* It may be said indeed that this belongs to the physical and material nature of man, and ought not to be compared with what has been done by the intellectual benefactors of mankind; the Miltons, the Shakspeares, and the Newtons. But is it quite certain that any thing short of the highest intellectual vigor—the brightest genius—is sufficient to invent one of these extraordinary machines? Place a common mind before an oration of Cicero and a steam engine, and it will despair of rivalling the latter as much as the former; and we can by no means be persuaded, that the peculiar aptitude for combining and applying the simple powers of mechanics, so as to produce these marvellous operations, does not imply a vivacity of the imagination, not inferior to that of the poet and the orator." And in concluding he asks,—"Has not he who has trebled the value of land, created capital, rescued the population from the necessity of emigrating, and covered a waste with plenty—has not he done

* The words of Mr. Justice Johnson of South Carolina, in the opinion in the case of Whitney *versus* Carter

a service to the country of the highest moral and intellectual character? Prosperity is the parent of civilization, and all its refinements; and every family of prosperous citizens added to the community, is an addition of so many thinking, inventing, moral, and immortal natures."

His tomb is after the model of that of Scipio at Rome. It is simple and beautiful, and promises to endure for years. It bears the following inscription.

ELI WHITNEY,
The inventor of the Cotton Gin.
Of useful science and arts, the efficient patron and improver.
In the social relations of life, a model of excellence.
While private affection weeps at his tomb, his country honors his memory.
Born Dec. 8, 1765.—Died Jan. 8, 1825.



DAVID BUSHNELL,

THE ORIGINATOR OF SUBMARINE WARFARE.

Early attempts at submarine navigation.—Drebell's boat.—The invention of an Englishman, for entering sunken ships.—Worcester.—Birth of Bushnell.—Early Character.—Receives a collegiate education.—Account of his first experiments.—Description of his submarine boat, and magazine.—Endeavors to blow up the British ship of war Eagle in the harbor of New York.—Blows up the tender of his Majesty's ship Cerberus, off New London.—Contrives a new expedient to destroy the British shipping in the Delaware.—"Battle of the Kegs."—Dejected at the issue of his experiments, leaves for France.—Returns and settles in Georgia.—His Death.

Since the invention of the diving bell in the sixteenth century, we have accounts of several projects for submarine navigation, among which the following are most prominent. "A scheme is said to have been tried in the reign of James the First, by Cornelius Drebell, a famous English projector, who, we are told by Mr. Boyle, made a submarine vessel which would carry twelve rowers, besides the passengers; and that he also discovered a liquid which had the singular property of restoring the air when it became impure by breathing. This last circumstance, with the number of persons enclosed in the machine and the imperfect state of mechanics at the period alluded to, renders the whole story extremely improbable, though it shows clearly that the idea had been entertained and perhaps some attempt made. Another contrivance is mentioned by Mr. Martin, in his Philosophia Britannica, as the invention of an Englishman, consisting of strong thick leather, which contained half a hogshead of air, so prepared that none could escape, and constructed in such a manner that it exactly fitted the arms and legs, and had a glass placed in the fore part of it. When he put on this apparatus he could not only walk on the ground at the bottom of the sea, but also enter the cabin of a sunken ship and convey goods out of it at pleasure. The inventor is said to have carried on his business for more than forty years, and to have grown rich by it."

It is evident from the perusal of the following pages, that the plans of Bushnell were almost entirely original; and he appears to

have greatly advanced, if not actually to have originated, submarine navigation. In its application as a means of warfare, we must give him the entire credit of originality; although Worcester in his Century or Hundred of Inventions, vaguely alludes to something of the kind, there is no evidence of its application, and as far as regards benefits to subsequent experiments, it is entirely useless.

The efforts of Bushnell in the revolutionary, and of Fulton during the late war, at the time attracted considerable attention, and greatly excited the fears* of the enemy. Although, for obvious reasons, the anticipated success did not attend these experiments, we must remember that "invention is progressive;" and while we hear them derided as visionary, we should reflect that such has ever been the fate, in their incipient stages, of the most useful inventions. The day may not be far distant, when another Bushnell will arise to advance submarine warfare to such perfection as to render it an important auxiliary in coast defence.

David Bushnell was born in Saybrook, Connecticut, some time about the year 1742. His parents were agriculturists of rather moderate circumstances, and resided in a very secluded part of the town. Here in attendance upon the duties of the paternal farm young Bushnell passed the earlier portion of his life, and is only remembered as being a very modest, retiring young man, shunning all society, and bound down to his books.

On the death of his father, which happened when he was about twenty-seven years of age, Bushnell sold his inheritance and removed to the central portion of the town for the purpose of preparing for college,—the attainment of a liberal education having long been with him an object of his most ardent wishes. As is customary in the New England villages, the pastor of the society, the Rev. John Devotion, assisted him in his studies.

One of his fellow townsmen Mr. Elias Tully, becoming acquainted with him and admiring his character, very generously offered him a home under his own roof, where he remained until his entrance into Yale college in 1771.

We are ignorant of the origin of Mr. Bushnell's conceptions respecting submarine warfare, but he appears to have turned his attention to the subject in the earlier portions of his collegiate career, so that on graduating in 1775, his plans were advanced to maturity.

* It is well known that during the experiments of Fulton, the British shipping were very cautious in approaching our shores. A gentleman, who was taken prisoner by a vessel of war in Long Island Sound, describes the anxiety of the officers as being so great, that they made a regular practice at certain times of day, of dragging ropes under the ship's bottom. This course, it is believed, was universally practised by the enemy while anchoring off our coast.

"The first experiment was made with about two ounces of gunpowder, to prove to some influential men that powder would burn under water. In the second trial there were two pounds of gunpowder enclosed in a wooden bottle, and fixed under a hogshead, with a two inch oak plank between the hogshead and the powder. The hogshead was loaded with stones as deep as it could swim; a wooden pipe primed with powder descended through the lower head of the hogshead, and thence through the plank into the powder contained in the bottle. A match put to the priming exploded the powder with a tremendous effect, casting a great body of water with the stones and ruins many feet into the air.

"He subsequently made many experiments of a similar nature, some of them with large quantities of powder, all of which produced very violent explosions, much more than sufficient for any purposes he had in view.

"When finished, the external appearance of his torpedo bore some resemblance to two upper tortoise shells of equal size, placed in contact, leaving, at that part which represents the head of the animal, a flue or opening sufficiently capacious to contain the operator, and air to support him thirty minutes. At the bottom, opposite to the entrance, was placed a quantity of lead for ballast. The operator sat upright and held an oar for rowing forward or backward, and was furnished with a rudder for steering. An aperture at the bottom with its valve admitted water for the purpose of descending, and two brass forcing pumps served to eject the water within when necessary for ascending. The vessel was made completely water-tight, furnished with glass windows for the admission of light, with ventilators and air pipes, and was so ballasted with lead fixed at the bottom as to render it solid, and obviate all danger of oversetting. Behind the submarine vessel was a place above the rudder for carrying a large powder magazine; this was made of two pieces of oak timber, large enough, when hollowed out, to contain one hundred and fifty pounds of powder, with the apparatus used for firing it, and was secured in its place by a screw turned by the operator. It was lighter than water, that it might rise against the object to which it was intended to be fastened.

"Within the magazine was an apparatus constructed to run any proposed period under twelve hours; when it had run out its turn, it unpinioned a strong lock, resembling a gun-lock, which gave fire to the powder. This apparatus was so pinioned, that it could not possibly move, until, by casting off the magazine from the vessel, it was set in motion. The skilful operator could swim so low on the surface of the water, as to approach very near a ship in the night, without fear of being discovered; and might, if he chose,

approach the stem or stern above water, with very little danger. He could sink very quickly, keep at any necessary depth, and row a great distance in any direction he desired without coming to the surface. When he rose to the top he could soon obtain a fresh supply of air, and, if necessary, descend again and pursue his course.

"Mr. Bushnell found that it required many trials and considerable instruction to make a man of common ingenuity a skilful operator. The first person whom he employed was his brother, who was exceedingly ingenious, and made himself master of it, but was taken sick before he had an opportunity to make a trial of his skill. Having procured for a substitute a sergeant of one of the Connecticut regiments, and given him such instructions as time would allow, he was directed to try an experiment on the Eagle, a sixty-four gun ship, lying in the harbor of New York, and commanded by Lord Howe. Gen. Putnam placed himself on the wharf to witness the result.

"The sergeant went under the ship and attempted to fix the wooden screw into her bottom, but struck, as he supposed, a bar of iron, which passed from the rudder hinge, and was spiked under the ship's quarter. Had he moved a few inches, which might have been done without rowing, there is no doubt he might have found wood where he could have fixed the screw;—or if the ship had been sheathed with copper, it might easily have been pierced. But for want of skill and experience in managing the vessel, in an attempt to move to another place, he passed out from under the ship. After seeking her in vain for some time, he rowed some distance and rose to the surface of the water, but found daylight so far advanced that he dared not to renew the attempt, for fear of being discovered by the sentinels on duty. He said he could easily have fastened the magazine under the stern of the ship, above water, as he rowed up and touched it before he descended. Had it been done, the explosion of the one hundred and fifty pounds of powder, contained in the magazine, must have been fatal to the ship.

"In returning from the ship to New York, the operator passed near Governor's Island, and thought he was discovered by the British stationed there. In haste to avoid the danger, he cast off his magazine, imagining it retarded him in the swell, which was very considerable. The internal apparatus was set to run just one hour; at the expiration of the allotted time it blew up with tremendous violence, throwing a vast column of water to an amazing height in the air, much to the astonishment of the enemy.

"Some other attempts were made on the Hudson, in one of

which the operator in going towards the ship lost sight of her, and went a great distance beyond. The tide ran so strong as to baffle all further effort.

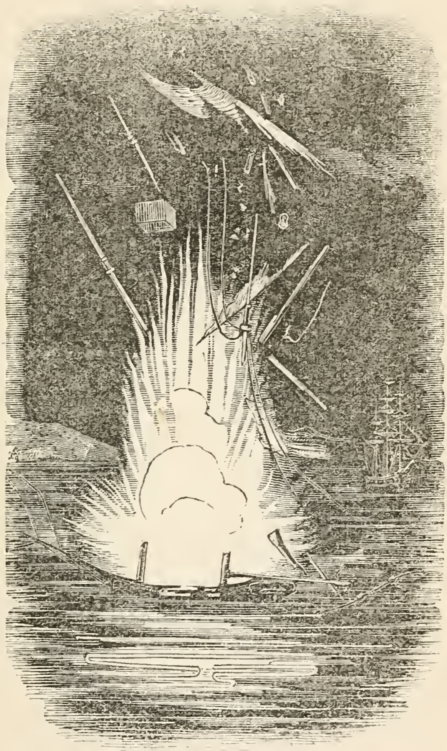
"In the year 1777, Mr. Bushnell made an attempt from a whale-boat against the Cerberus frigate, lying at anchor off New London, in drawing a machine against her side by means of a line. The machine was loaded with powder to be exploded by a gun-lock, which was to be unpinioned by an apparatus to be turned by being brought along side of the frigate. This machine fell in with a schooner at anchor astern of the frigate, and becoming fixed, it exploded and demolished the vessel.

"Commodore Simmons being on board of the Cerberus, addressed an official letter to Sir Peter Parker, describing this singular disaster. Being at anchor to the westward of the town with a schooner which he had taken, about eleven o'clock in the evening he discovered a line towing astern from the bows. He believed that some person had veered away by it, and immediately began to haul in. A sailor belonging to the schooner taking it for a fishing line, laid hold of it and drew in about fifteen fathoms. It was buoyed up by small pieces tied to it at regular distances. At the end of the rope a machine was fastened too heavy for one man to pull up, for it exceeded one hundred pounds in weight. The other people of the schooner coming to his assistance, they drew it upon deck. While the men, to gratify their curiosity, were examining the machine, it exploded, blew the vessel into pieces, and set her on fire. Three men were killed, and a fourth blown into the water, much injured. On subsequent examination the other part of the line was discovered buoyed up in the same manner; this the commodore ordered to be instantly cut away, for fear (as he termed it) of 'hauling up another of the *infernals !*'

"These machines were constructed with wheels furnished with irons sharpened at the end, and projecting about an inch, in order to strike the sides of the vessel when hauling them up, thereby setting the wheels in motion, which in the space of five minutes causes the explosion. Had the whole apparatus been brought to act upon a ship at the same time, it must have occasioned prodigious destruction.

"Mr. Bushnell contrived another ingenious expedient to effect his favorite object. He fixed a large number of *kegs*, charged with powder, to explode on coming in contact with any thing while floating along with the tide.

"In December, 1777, he set his squadron of kegs afloat in the Delaware above the British shipping. The kegs were set adrift



DESTRUCTION OF A BRITISH TENDER BY A TORPEDO.

in the night, to fall with the ebb on the shipping; but the proper distance could not be well ascertained, and they were set adrift too remotely from the vessels, so that they were obstructed and dispersed by the ice. They approached, however, in the day-time, and one of them blew up a boat, others exploded, and occasioned the greatest consternation and alarm among the British seamen. The British soldiers actually manned the wharves and shipping at Philadelphia, and discharged their small arms and cannon at every thing they could see floating in the river during the ebb tide. This incident has received the name of '*the Battle of the Kegs*,' and has furnished the subject of an excellent and humorous song by the Hon. Francis Hopkinson, which, as it is an amusing relic of the times, we here insert."

THE BATTLE OF THE KEGS:—A SONG.

TUNE—"*Moggy Lawder.*"

GALLANTS attend, and hear a friend
Trill forth harmonious ditty;
Strange things I'll tell, which late befell
In Philadelphia city.

'Twas early day, as poets say,
Just when the sun was rising,
A soldier stood on log of wood,
And saw a sight surprising.

As in amaze he stood to gaze,—
The truth can't be denied,—
He spied a score of kegs, or more,
Come floating down the tide.

A sailor too, in jerkin blue,
The strange appearance viewing,
First "d—d his eyes," in great surprise,
Then said, "some mischief's brewing:

"These kegs now hold the rebels bold,
Pack'd up like pickled herring;
And they're come down t'attack the town
In this new way of ferrying."

The soldier flew,—the sailor too,—
And almost scared to death,
Wore out their shoes to spread the news,
And ran till out of breath.

Now up and down, throughout the town
Most frantic scenes were acted;
And some ran here and some ran there
Like men almost distracted.

Some *fire!* cried, which some denied,
But said, the earth had quaked:
And girls and boys, with hideous noise,
Ran through the streets, half naked.

HOWE, in a fright, starts upright,
Awoke by such a clatter;
Rubbing both eyes, he loudly cries,
"For God's sake, what's the matter?"

At his bedside he then espied
Sir ERSKINE at command;
Upon one foot he had one boot,
And t'other in his hand.

"Arise! arise!" Sir ERSKINE cries;
"The rebels—more's the pity—
Without a boat are all afloat,
And rang'd before the city;

"The motley crew, in vessels new,
With SATAN for their guide,
Pack'd up in bags, or wooden kegs,
Come driving down the tide;

"Therefore prepare for bloody war;
These kegs must all be routed,
Or surely we despised shall be,
And British courage doubted."

The royal band now ready stand,
All rang'd in dread array,
With stomachs stout, to see it out,
And make a bloody day.

The cannons roar from shore to shore,
The small arms make a rattle;
Since war began, I'm sure no man
Ere saw so strange a battle:

The rebel vales, the rebel dales,
With rebel trees surrounded;
The distant woods, the hills and floods,
With rebel echoes sounded.

The fish below swam to and fro,
Attack'd from every quarter;
"Why sure," thought they, "the devil's to pay
'Mongst folks above the water."

The kegs, 'tis said, though strongly made
Of rebel staves and hoops,
Could not oppose their pow'rful foes,
The conq'ring British troops.

From morn to night, these men of might
Display'd amazing courage:
And when the sun was fairly down,
Retir'd to sup their porridge.

A hundred men, with each a pen,
Or more, upon my word,
It is most true, would be too few
Their valor to record:

Such feats did they perform that day
Upon those wicked kegs,
That years to come, if they get home,
They'll make their boast and brags.

The unfortunate issue of Mr. Bushnell's efforts rendered him very dejected. He had been disappointed in his expected support from government, having spent nearly all, if not the whole of his own property in the course of his experiments. Soon after the close of the war, he left his native country for France. The object of this voyage is not known; and it was always supposed, until within a very short time, that he had perished amid some one of the sanguinary scenes of the French revolution. But it appears that, after remaining in Europe a number of years, he returned and settled in Georgia, under the assumed name of Bush, where he lived in a retired manner, gaining his livelihood by the practice of medicine. The tidings of his death, in 1826, accompanied by a handsome bequest, the product of his professional industry, was the first information his relations had received of him for a period of nearly forty years.

AMOS WHITTEMORE,

THE INVENTOR OF THE CARD MACHINE.

Birth.—Early traits of character.—Is apprenticed to a gunsmith.—Industry.—Constructs a wooden clock without a model.—Invents a machine for measuring the progress of vessels.—Becomes a partner in manufacturing cotton and wool cards.—Description and imperfection of the old method of making cards.—Sets about the construction of the card machine.—Wonderful perseverance.—Meets with an unexpected obstacle.—Overcomes the difficulty *in a dream.*—Completes the invention.—Its beauty and precision.—Secures the patent.—Visits England, to secure a patent there.—Taken prisoner by a French man-of-war.—Release.—Dyer's card establishment at Manchester.—Return.—Forms a copartnership to manufacture card machines.—Slow progress and exhausted means.—Visits Washington, and exhibits the invention.—It excites universal admiration.—Congress renews the patent.—Establish a branch in New York.—The New York Manufacturing Company purchase their whole interest.—Its succeeding history.—Phœnix Bank.—Singular chain of circumstances.—Whittemore purchases a country seat, and retires from active life.—Projects an orrery on a new plan.—Feeble health.—Death.—Character.—Value of the card machine.—Conclusion.

The incidents in the following memoir are principally such as could be gathered from the memory of one who intimately knew the subject of it while living, and always entertained for him and his memory a high regard. The writer therefore feels some diffidence in recording as strict fact, every part of the relation made to him, inasmuch as the lapse of years may have effaced in some degree the recollection of many of the events. It is believed, however, that its leading features are essentially correct, and as nothing stated can affect others, he feels relieved from responsibility.

Amos Whittemore, who, by his extraordinary invention for making cotton and wool cards, merits a prominent place among the first mechanics of the age, was the second of five brothers, and was born in Cambridge, Massachusetts, April 19th, 1759. His father was an agriculturist of but moderate means, whose industry enabled him to rear a large family, and give to his children the mere rudiments of an English education. Of the five brothers, it is unnecessary to allude to either than the two next in age, William and Samuel, who, as will appear in the sequel, became interested in business with that brother whose ingenuity laid the foundation of their fortunes.

The youthful days of Whittemore were passed in the usual manner of lads in the country, chiefly in assisting his parent in

the cultivation of the farm. At an early age he manifested a remarkable talent for mechanical pursuits, together with a mind disposed to the contemplation of philosophical and abstruse science.

Aware that he must depend almost entirely upon his own resources, not only for his maintenance. but for his future advancement, it was obvious that he must soon choose a profession which would promote these ends. Free to make his own choice, he selected the trade of a gunsmith, as one which, while it presented a field for the cultivation of mechanical taste, offered the prospects of a fruitful harvest.

On becoming an apprentice, he not only zealously applied him self to the interests of his master, but devoted his leisure to voluntary employment. At this period he invented many ingenious and useful implements; and such was his proficiency, that long ere the expiration of his term of service, his employer confessed himself unable to give further instruction, and advised him to commence business for himself.

Among the many instances of his skill, may be noticed that of an excellent clock made without a model, which remained many years in the family, proving a useful, as well as gratifying memento of his early ingenuity. This was among the first of the kind, although now there is scarcely a cottage in our wide spread country that does not boast of at least one of these indispensable as well as ornamental pieces of furniture. He also invented a machine constructed with dial hands and figures, to be placed in the water at a vessel's stern, for the purpose of accurately measuring its progress. At the suggestion of a medical friend, a Dr. Putnam of Charlestown, he invented a self-acting loom, for weaving duck, which, from the best information we possess, is believed to be the same in principle as the celebrated power loom now so universally used. Owing to the unsettled state of business at this period, and the want of encouragement in the useful arts, these productions, notwithstanding their value, were suffered to lie neglected and forgotten.

For years succeeding the expiration of his apprenticeship, Whittemore was variously, though to himself, in a pecuniary point, unprofitably employed. At length he became interested with his brother William, and five others, in the manufacture of cotton and wool cards, conducting their business in Boston under the firm of Giles, Richards, and Co., and supplying nearly all the cards then used in the country. Amos devoted himself to the mechanical department, as being the most agreeable and useful.

Hitherto, the manufacture of cotton and wool cards, which had already become an article of great demand, was attended with

much expense, owing to the imperfection of the machinery, and the amount of manual labor required. But two machines, and those of simple construction, were as yet known; one for cutting and bending the wire into staples, and another for piercing the sheets of leather with holes, into which the staples were placed, one by one, with the hand. This last operation gave employment to hundreds of the younger members of families in New England: and it was not unamusing to witness groups of children, of both sexes, engaged in this easy labor, their tiny fingers rapidly placing staple after staple into its appropriate place, as eager to perform their allotted task as they were to count the few pence earned at the dear expense of a temporary deprivation of their youthful sports. This, the only method then known, combined both the disadvantage of great expense and the impossibility of making the cards sufficiently perfect to properly prepare the raw material.

Whittemore, ever bent upon improvements in machinery, at once saw the importance, and, of course, the immense value of a machine so constructed as to be enabled, by its own independent action, to hold the sheet of leather, pierce the holes, draw the wire from the reel, and shape and stick it into its proper place: thus, by the combination of a series of successive independent operations, complete the card. After that mature reflection which always characterized him, he imparted to his brother William the conception of that idea which he so ardently desired to execute. Encouraged by the advice and assistance of this brother, he engaged in the apparently insurmountable task, well convinced of the rich reward awaiting him if he could but embody in a machine the picture of his imagination. With ardor and unremitting zeal he prosecuted his labors, devoting his whole mental and physical energies to the undertaking. Such was his diligence, and so incessantly did it occupy his time, that he not only impaired his health, but frequently neglected the demands of nature, to the extent that food and sleep seemed to him of but secondary consequence. Slowly, but steadily he progressed; and while his bodily strength daily diminished, the fire of his mind seemed to burn with increased enthusiasm. Like the discoverer of our western world, he had staked, as it were, his reputation upon this effort, and, though storms of discouragement buffeted him at every point, and a boundless sea of toil appeared between him and his uncertain haven, yet he undauntingly persevered almost against hope.

Baffled as was his skill to the utmost, he at length so far completed his machine as to cause it to draw the wire from the reel, cut and shape it, pierce the holes in the leather, and even place the staples firmly in the sheet; but it was yet necessary to bend the

wire after it was placed: without this, all was in vain; time and health had been valuelessly sacrificed, and that ambition that ever animates to action the inventive mind, seemed in him about to receive a fatal check. Notwithstanding the encouragement of his friends—who, believing that he could finally succeed, were, if possible, more zealous than himself—he gradually became irresolute, and frequently declared his inability to make any farther progress.

The labor of nearly three months lay before him, an unfinished, yet wonderfully ingenious structure; but, like the famed ivory balls of the Chinese, while it was admirable for the skill displayed in its workmanship, was valueless. Fortunately, he was not long doomed to look upon his work as a mere monument of labor lost. While the ingenuity of his mind had in vain been taxed to the utmost, it was, as it would seem, to miraculous interposition that he owed his ultimate success. Extraordinary as it may appear, and doubted as it may be by some, it is, nevertheless, a fact, that during a night succeeding a day of despondency and gloom, and at an hour when his faculties were wrapped in slumber, in *a vision* was disclosed to him the complete accomplishment of his hopes. Scarcely had the following day dawned, when, with a heart swelling with emotions of eagerness and joy, he once more revisited the chamber where he had so earnestly toiled, and, ere he broke his fast on that morning, he was enabled to announce to his brother and friends his entire success.

Thus, within the short space of three months, he had, by untiring industry, commenced and completed an invention which at once revolutionized the manufacture of cards, and which, for ingenuity of construction, precision of movement, rapidity of performance, and perfection of execution, may challenge comparison with any mechanical effort of the human mind. It must be studiously examined to be justly appreciated; and, with a distinguished man* of our day,—one alike eminent for his scientific attainments as for his accomplishments as a statesman,—we may say, that those who examine its complicated performance can compare it with nothing more nearly than the machinery of the human system.

This anecdote, so intimately connected with the invention, was one which Whittemore frequently related, and it was gratifying to observe with what ardor he told the story of his toil; upon no part of which would he dwell with more enthusiastic delight than this singular dream.

The brothers, fully aware, if successful, of the value of such a machine, had, in a measure, kept secret the fact of Whittemore's

* Edward Everett.

being engaged in its construction. When, therefore, completed, steps were immediately taken to secure to the fortunate inventor, and his associates, the pecuniary advantages to be derived; and on the 2d of June, 1797, a patent right was granted for a term of fourteen years. The importance of securing a patent right in England, as well as in the United States, was not lost sight of. At this time, during the administration of the elder Adams, but few years had elapsed since the establishment of our national independence, and the relations of our country with England were unsettled, while with France we were engaged in naval hostilities. To undertake a voyage across the Atlantic, under such circumstances and at this early period, was considered of almost as much importance as, in our time, to circumnavigate the globe. To many of the habits of Whittemore, the project of visiting England, and there to wade through the difficulties of securing a patent, would have been thought too great an enterprise: at most, that the advantages to accrue would not be commensurate with the risk and expenditure. Not so thought the brothers; and the requisite arrangements being made, it became the duty as well as pleasure of Whittemore to visit that country. At this period, but two ships traded regularly between Boston and London, the Galen and the Minerva; in the latter of which he embarked in the spring of 1799, accompanied by an English gentleman named Sharpe, who evinced great interest in the machine, and is believed to have been largely benefited by it in England.

Being unacquainted with the circumstances connected with this visit, it is out of our power to give a detail of its events; it is sufficient, however, to know, that the invention soon became fully appreciated, and though numerous offers were made, either to purchase the right or become interested in its profits, nothing of consequence was done to remunerate the inventor. Anxious to return, he left his business in the hands of those in whom he reposed confidence, and in the spring of 1800 sailed for Boston, where he arrived in safety after a passage of fifty-nine days, and a year's absence from home. Either on his outward or homeward voyage, the vessel which he was in was captured by the French, but the passengers were released without serious inconvenience.

Justly entitled as he was to a rich reward in that country, which has since been so largely benefited by this invention, he was despoiled of his rights, and realized little else than expense and labor.

No sooner was the machine generally understood in England, than it was perceived how fatal its successful operation would become to the working classes engaged in the manufacture of cards. The greatest caution and secrecy were therefore observed, lest the

threats of the people, to mob those engaged in making the machinery, would be carried into execution. The only safe method was, to have parts of the machine made in different places, and put together when finished.

The most extensive, if not the only establishment now in operation in England for manufacturing machine cards, is that of Mr. Dyer, in Manchester, who has conducted the business with great success; through whose agency the machinery has been carried into France and the other parts of the continent, and is even supposed by many to be his invention, though he himself acknowledges its proper source.

The copartnership of Giles, Richards, and Co. having expired some time, Whittemore, with his brother, had been engaged in the manufacture of cards upon the old plan. On his return from England, they formed a connection with their friend, Mr. Robert Williams, of Boston, who possessed the requisite means for carrying on the business with the improved machinery, though on a limited scale.

Until the year 1809, little had been done beside constructing expensive machines, and making the necessary preparations for the manufacture of cards. The patent was at this time within two years of its expiration, and their treasury nearly exhausted. Serious apprehensions were therefore entertained that, when about to realize a remuneration for their time and expense, others, by successful competition, would step in and wrest from them the fruits of all their toils.

During the session of the congress of 1808 and 1809, Whittemore, with his brother William, visited Washington, carrying with them a complete machine, of full size, as a model for exhibition, which was shown to the members and other men of distinction. It not only elicited universal admiration, but of such advantage was it considered to the country, especially to the cotton and wool-growing interest, that many members, among them Matthew Lyon of Vermont, a gentleman distinguished for his abilities, were disposed to grant a perpetual patent to the inventor and his heirs. The result, however, was, that on the 3d of March, 1809, an act received the unanimous vote of congress, granting a renewal of the patent for fourteen years from the expiration of the first term.

The city of New York had long since given evidence of it peculiar advantages for trade and commerce; and as early as the year 1803, a branch of the business was established in that city, under the management of a younger brother, Mr. Samuel Whittemore, who became a partner with the brothers. As may be

readily supposed, the importance of the machine attracted no little attention among the enterprising of this metropolis; and soon after the renewal of the patent, efforts were made to establish a company, with a capital of sufficient magnitude to carry on an extensive business, and thus obtain the certain profit that a monopoly such as this seemed to ensure.

Men of fortune and energy gave it their support; and during the session of the New York legislature of 1812, an act was passed, incorporating the "New York Manufacturing Company," with a capital of about $800,000, of which $300,000 was directed to be employed in manufacturing cotton and wool cards, and building the necessary machinery and factories, while the balance was to be employed in banking.

Among the first acts of this company, was to purchase of the Messrs. Whittemore their patent right and entire stock of machinery; which was effected on the 20th of July, 1812, for the sum of one hundred and fifty thousand dollars. The company having purchased a site on New York island, commenced the erection of extensive works; and the usual custom in public buildings of laying the corner stone, was here observed with much ceremony. And now for the first time, it may be said, that the business had commenced on favorable auspices, so far as capital and an intelligent direction was a guarantee of success.

Our country, being at this time engaged in an active, and to our commerce, a destructive warfare with England, a country that had always supplied us with cotton and woollen, as well as other goods, a check, if not a total suspension, was thus placed upon farther importations, and the manufacture of these fabrics was thrown upon ourselves. Cotton and woollen factories were erected as if by the magic of Aladdin's lamp, and they, with the demand from all parts of the country for hand cards, gave such an impetus to the business that the company were most actively and profitably engaged.

But the peace of 1815, an event, so much and so devoutly wished for by our suffering country, proved injurious to the association. Sudden and immense importations of foreign goods followed this event, and such was the insufficient protection then afforded to domestic industry, and so great was the demand for the raw material abroad, that our infant manufactories were compelled to stop, and scarcely a pound of cotton or wool remained at home. The company thus found themselves with a large stock of machinery and cards, and no market. In the year 1818, after waiting in vain for a reaction, and the business being doubtless shackled by the unwieldy management of a corporation, the company proposed and effected a sale of its entire manufacturing property to Messrs.

Samuel and Timothy Whittemore, the former a brother, the latter a son of the inventor. Mr. Timothy Whittemore almost immediately thereafter relinquished his interest to his uncle, who became the sole proprietor, and conducted the business with varied success until within a few years. The New York manufacturing company, after this sale, with an increased capital, changed its title to that of the "Phœnix Bank," and continues to this day a popular banking institution.

At the expiration of the patent in 1825, Mr. Samuel Whittemore sold several of his machines in anticipation of a rapid decline in the business, since the monopoly could no longer be retained; and from that time the manufacture of cards by machinery has become so general, as to make it a business of comparatively small amount to any, but to a few old established firms. By a singular, though interesting chain of circumstances, the identical machines which the inventor himself assisted in building, after being out of his family for more than twenty-five years, have now become the property of his sons, and are used by them in West Cambridge, a small town near that which gave him birth. Their cards are well known for their uniform excellence, the stamp being to the consumer a sufficient guarantee of their quality.

Although more than forty years have elapsed since the invention, such was the perfection with which it came from the mind of the inventor, that no essential improvements have ever been suggested. Attempts were frequently made to defraud him of his well-earned fame, by claiming it as the production of others, but they have proved as abortive as the attempts to infringe upon the patent.

After the sale of his interest, Whittemore retired from active life, and having purchased a pleasant estate in the town of West Cambridge, found that quiet and freedom from the many cares of business life, so agreeable to his nature. Since the invention, he never seriously exerted his mechanical ingenuity, feeling, doubtless, content with the laurels already acquired. Having, however, in early life entertained a deep interest in the science of astronomy, in later years he conceived the plan of a complete orrery, representing the whole planetary system, each planet to describe its own orbit, and the combination acting like nature's own. Enfeebled by an impaired health, and the infirmities of age, he never matured this project, and at length he died, in the year 1828, at the age of sixty-nine, at his residence in West Cambridge, leaving a widow to lament the loss of a kind husband, his children an indulgent father, and his associates an amiable and devoted friend. To his family he was an example of one who lived a pure and blameless life; and though he left but an inconsiderable fortune, they

inherited a far brighter treasure in an unsullied reputation. Whittemore was of a bland and conciliating disposition, even in temper, and in manners strikingly meditative, conversing but little, and often seen in profound mental study.

The value that the card machine has been, and still is, not to this country alone, but to the whole manufacturing world, it is believed even few now justly appreciate. With Whitney's cotton gin, it forms an important and necessary link in the chain of machinery which by their operation furnish to the world one of the most useful, as well as beautiful fabrics. How far it may have contributed, not only to perfect in quality, but to reduce it in cost, cannot be difficult to estimate. We may add, however, in conclusion, that not a cotton or wollen factory is reared, that does not rely upon the card machine to complete its own machinery, and the use of the hand card, in the southern states, has become as general as the culture of cotton itself.

ROBERT FULTON.

Birth and parentage.—Early ingenuity.—Becomes a painter.—Visits England.—Becomes an inmate in the family of Benjamin West.—Inland navigation.—Excavating machine.—Visits France.—Turns his attention to submarine warfare.—Experiments.—British Government.—Bonaparte.—Constructs a plunging-boat, with which he remains under water an hour.—Blows up a vessel in the harbor of Brest with a submarine bomb.—Revisits England.—Blows up a Danish brig.—Returns to the United States.—Anecdote.—Stationary torpedo.—Congress appropriate funds to carry on his experiments.—Report of the commissioners.—Letter to the secretary of the navy.—Experiments on the sloop of war Argus.—Gun-harpoon and cable-cutter.—Steam navigation.—Chancellor Livingston.—Fulton's steam experiments in France.—Experiments with a steamboat on the Seine.—Commences building a steamboat in New York.—Orders an engine from England.—Description and success of the first experiment on the Hudson.—Redheffer's perpetual motion.—Builds a floating steam battery for government.—Launch.—Voyage of "Fulton the First."—Lawsuits.—Death.—Conclusion.

THIS indefatigable man was born in Little Britain, Lancaster county, Pennsylvania, in the year 1765, of a respectable, though not opulent family. His father was a native of Kilkenny, in Ireland, and his mother was of a respectable Irish family, residing in Pennsylvania. He had two sisters older than himself, besides a younger brother and sister. His patrimony was very small. In his infancy he received the rudiments of a common English education, and his peculiar genius manifested itself at a very early age. All his hours of recreation were passed in the shops of mechanics, or in the use of his pencil. By the time he had attained the age of seventeen, he became so much of an artist, as to derive emolument from portrait and landscape painting in Philadelphia, where he remained till he was about twenty-one.

When he became of age, he went to Washington county, and there purchased a little farm, on which he settled his mother, his father having died in 1768. After seeing his parent comfortably established in the home which he had provided for her, he set out with the intention of returning to Philadelphia. On his way, he visited the warm springs of Pennsylvania, where he met with some gentlemen, who were so much pleased with the genius they discovered in his paintings, that they advised him to go to England, where they assured him he would meet with the patronage of his

countryman Mr. West, who had, even then, attained great celebrity. Mr. Fulton went to England, and his reception by Mr. West was such as he had been led to anticipate. That distinguished American was so well pleased with his promising and enterprising genius, and his amiable qualities, that he took him into his house, where he continued an inmate for several years. After leaving the family of Mr. West, he appears to have made the art of painting his chief employment for some time. He spent two years in Devonshire, near Exeter, where he made many respectable acquaintances; among others, he became known to the duke of Bridgewater, so famous for his canals, and Lord Stanhope, a nobleman celebrated for his love of science, and particularly for his attachment to the mechanic arts. With Lord Stanhope, Mr. Fulton held a correspondence for a long time, and they communicated to each other ideas on subjects towards which their minds were mutually directed.

In 1793, we find Mr. Fulton actively engaged in a project to improve inland navigation; for, even at that early day, he had conceived the idea of propelling vessels by steam, and he speaks in his manuscripts with great confidence of its practicability. In May, 1774, he obtained from the British government a patent for a double inclined plane, to be used for transportation. An account of this may be seen in vol. xvii. of the Repertory of Arts.

What were Mr. Fulton's pursuits for some years after this period it does not appear. In his preface to a description of his Nautilus, or plunging-boat, he says, that he had resided eighteen months in the great manufacturing town of Birmingham, where he must have acquired some of that practical knowledge in mechanics which he made so useful to his country, and indeed to all the world. In 1804, when Mr. Fulton left Paris, he sent a large collection of his manuscripts to this country; but unfortunately, the vessel in which they were sent was wrecked. The case containing the papers was recovered, but only a few fragments of the manuscripts were preserved. These, however, mark the genius of Fulton, and increase our regret that any productions of his strong and original mind which he thought worth preserving should be lost. It is owing to this misfortune that we have so few traces of Mr. Fulton's occupations at this period. But a mind like his could never be idle, and it is evident that, at this time, it was still directed towards his favorite pursuits.

In 1794, he submitted to the British Society for the Promotion of Arts and Commerce, an improvement of his invention in mills for sawing marble, for which he received the thanks of the society and an honorary medal. He invented also, as is presumed, about

this time, a machine for spinning flax, and another for making ropes, for both of which he obtained patents from the British government. A mechanical contrivance for scooping out earth in certain situations, to form the channels for canals or aqueducts, which, as it is understood, has been much used in England, is also his invention. Indeed, the subject of canals appears chiefly to have engaged his attention at this time. He now, and probably for some time previous, professed himself a civil engineer, and under this title he published his work on canals, and in 1795, some essays on the same subject in the London Morning Star. In 1796, he published in London, his Treatise on the Improvement of Canal Navigation, in which he recommends small canals and boats of little burden; and also inclined planes instead of locks, together with the various contrivances necessary to effect the passage of boats from one level to another. His plans were strongly recommended by the British Board of Agriculture, of which Sir John Sinclair was president.

Mr. Fulton, throughout his course as a mechanist and civil engineer, derived great advantages from his talent for drawing and painting. He was an elegant and accurate draughtsman, which is proved by the plates annexed to the work we have mentioned. This gave him great facility in procuring the execution of his designs, and a great advantage over most who have engaged in similar pursuits. He seems, however, to have neglected his pencil as a painter for many years, till a short time before his death, when he resumed it to paint some portraits of his own family, and his success in executing these gave him much pleasure.

Mr. Fulton, ever thoughtful of the interests of his own country, sent copies of his works to distinguished persons in America, accompanied with letters, setting forth the advantages to be derived from internal communication by canals.

Having obtained a patent for canal improvements from the British government, he went to France, with the intention of introducing them there; but not meeting with much encouragement, he soon directed his mind to other important subjects; though the canal system still occupied a portion of his thoughts. About this time, his thoughts were turned towards the subject of political economy, and he wrote a work, addressed to "the Friends of Mankind," in which he labors to show, that *education* and *internal improvements* would have a good effect on the happiness of a nation. He not only wished to see a free and speedy communication between the different parts of a large country, but a universal free trade between all nations. He saw that it would take ages to establish the freedom of the seas by the common consent of na

tions; he therefore turned his whole attention to find out some means of destroying ships of war, those engines of oppression, and to put it out of the power of any nation to maintain such a system; and thus to compel every government to adopt the simple principles of education, industry, and a free circulation of its produce. Out of such enlarged and philanthropic views and reflections grew Mr. Fulton's inventions for submarine navigation and explosions, and with such patriotic motives did he prosecute them. Of these inventions we now proceed to give some account.

In the year 1797, he became acquainted with Mr. Joel Barlow, our celebrated countryman, then residing in Paris, in whose family he lived seven years, during which he learned the French, and something of the German and Italian languages. He also studied the high mathematics, physics, chemistry, and perspective.

In December, 1797, he made an experiment in company with Mr. Barlow, on the Seine, with a machine which he had constructed, and by which he designed to impart to carcasses of gunpowder a progressive motion under water, and there to explode them; but he was disappointed in its performance. He continued, however, to make experiments with a view to the accomplishment of his object, until he had perfected the plan for his submarine boat.

A want of funds to enable him to carry his design into execution, induced him to apply to the French Directory. They at first gave him reason to expect their aid, but after a long attendance at the public offices, he received a note, informing him that they had totally rejected his plan. Mr. Fulton was not to be discouraged, but pursued his inventions; and having executed a handsome model of his machine, and a change in the directors having taken place, he presented his plan, and a commission was appointed to examine his pretensions; but after three months attendance, he was again disappointed by finding his plan entirely rejected. Not yet, however, discouraged, he offered his project to the British government, through the ambassador from Holland; but without success. although a commission was appointed to examine his models. But the French government at length changed; and Bonaparte having placed himself at the head of it, Mr. Fulton presented an address to him, on which a commission was immediately appointed and assistance afforded, which enabled him to put some of his plans in practice. In the spring of 1801, Mr. Fulton repaired to Brest, to make experiments with the plunging-boat which he had constructed the preceding winter. This, as he says, had many imperfections natural to a first machine, and had been injured by rust, as parts which should have been of copper or brass were made of iron.

Notwithstanding these disadvantages, he engaged in a course of experiments, which required no less courage than energy and perseverance. From a report of his proceedings to the committee appointed by the French executive, we learn, that on the third of July, 1801, he embarked with three companions on board his plunging-boat in the harbor of Brest, and descended to the depth of five, ten, fifteen, and so on to twenty-five feet; but he did not attempt to go lower, because he found that his imperfect machine would not bear the pressure of the water at a greater depth. He remained below the surface an hour in utter darkness, which was very unpleasant, and candles were found to consume too much of the vital air; so he caused a small window of thick glass to be made near the bow of his boat, which afforded him light enough to count the minutes on his watch. Having satisfied himself that he could have sufficient light under water; that he could do a long time without fresh air, and descend to any depth or rise to the surface with facility; his next object was to try the movements of his vessel, as well on the surface as under it. He found that she would tack and steer, and sail on a wind or before it, as well as any common sailing boat. He then struck her masts and sails; to do which, and prepare for plunging, required about two minutes. Having plunged to a certain depth, he placed two men at the engine, which was intended to give her progressive motion, and one at the helm, while he, with a barometer before him, kept her balanced between the upper and lower waters. He found that with one hand he could keep her at any depth he pleased; and that in seven minutes he had gone about the third of a mile. He could turn her round while under water, and return to the place he started from. These experiments were repeated for several days, till he became familiar with the operation of the machinery and the motion of the boat. He found that she was as obedient to her helm under water as any boat could be on the surface; and that the magnetic needle traversed as well in one situation as in the other.

On the 7th of August, Mr. Fulton descended with a store of air compressed into a copper globe, whereby he was enabled to remain under water four hours and twenty minutes. The success of these experiments determined him to try the effects of these inventions on the English ships, which were daily near the harbor of Brest. Satisfied with his boat, he next made some experiments with the torpedoes, or submarine bombs. A small vessel was anchored in the roads, and with a bomb containing about twenty pounds of powder, he approached within about two hundred yards, struck the vessel and blew her into atoms. A column of water and frag-

ments was blown near one hundred feet into the air. This experiment was made in the presence of the prefect of the department and a multitude of spectators.

Through the summer of 1801, and till the project was relinquished on account of the season, Mr. Fulton appears to have been watching the English ships which were on the coast; but though some of them daily approached off the harbor, yet none of them came so near, or anchored in such a situation, as to be exposed to the effects of his attempts. In one instance, he came very near a British seventy-four; but she, just in time, made such a change of position as to save herself. The rulers of France were discouraged by this want of success, or rather of opportunity, and, so far from being willing to make farther advances for new experiments or efforts, they showed no disposition to fulfil the engagements they had already made with Mr. Fulton. The escape of the enemy's vessels seems to have lowered his invention so much in their estimation, that they refused to give him any farther encouragement.

The English had some information respecting the attempts which their enemies were making, but did not know to what extent they had been carried. Much anxiety was expressed, which induced the British minister to communicate with Mr. Fulton, the object of which was to deprive France of his services, and secure them to England. In this he was successful, and Mr. Fulton was induced to proceed to London, where he arrived in May, 1804. He soon had an interview with Mr. Pitt and Lord Melville. When Mr. Pitt first saw a drawing of a torpedo, with a sketch of the mode of applying it, and understood what would be the effect of the explosion, he said that if it were introduced into practice, it could not fail of annihilating all military marines; and when Mr. Fulton exhibited his torpedo and described its effects to the Earl St. Vincent, he exclaimed, in the strong language of his profession, against this mode of warfare, which, he said, with great reason, they who commanded the seas did not want, and which, if successful, would wrest the trident from those who claimed to bear it as the sceptre of supremacy over the ocean. From the subsequent conduct of the British ministry, it may well be supposed that they never truly intended to give Mr. Fulton a fair opportunity of trying the effects of his engines. The object may have been to prevent them from being placed in the hands of an enemy; and if this was accomplished, it was the interest of England, as long as she was ambitious of the proud title of mistress of the seas, to make the world believe that Mr. Fulton's projects were chimerical. Nothing would be more likely to produce this effect than abortive attempts to apply them. Several experiments were made, and

some of them were failures; but on the 15th of October, 1805, he blew up a strong built Danish brig of 200 tons burden, which had been provided for the experiment, and which was anchored in Walmar roads, near the residence of Mr. Pitt. The torpedo used on this occasion contained 170 pounds of powder; and in fifteen minutes from the time of starting the machinery and throwing the torpedo into the water, the explosion took place. It lifted the brig almost entire, and broke her completely in two. The ends sunk immediately, and in one minute nothing was to be seen of her but floating fragments. In fact, her annihilation was complete.

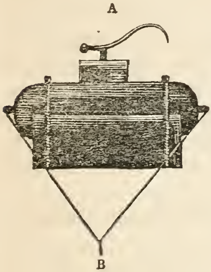
Notwithstanding the complete success of this experiment, the British ministry seem to have been but little disposed to have any thing farther to do with Mr. Fulton or his projects. Indeed, the evidence it afforded of their efficacy may have been a reason for this conduct. After some further experiments, of which we have no particular account, he at length embarked for his native country, and arrived at New York on the 13th of December, 1806.

Upon his arrival in this country, he immediately engaged in the projects, both of submarine war and steam navigation. For the last he had made some preparations before he left England; but we intend to postpone this important subject, to be presented in one view, after tracing the progress of his other pursuits.

So far from being discouraged by his attempts at applying his torpedoes in Europe, his confidence was unabated, because he saw, as he said, that his failures were to be attributed to trivial errors, which actual experience only could discover, and which could be easily corrected. He very soon induced our government to afford him the means of trying further experiments, and invited the magistracy of New York and a number of citizens to Governor's Island, where were the torpedoes and machinery with which his experiments were to be made; and while he was explaining his blank torpedoes, which were large copper cylinders, his numerous auditors crowded around him. At length he turned to a copper case of the same description, which was placed under the gateway of the fort, and to which was attached a clockwork lock. This, by drawing out a peg, he set in motion, and then said to his audience: "Gentlemen, this is a charged torpedo, with which, precisely in its present state, I mean to blow up a vessel. It contains 170 pounds of powder; and if I were to suffer the clockwork to run fifteen minutes, I have no doubt but that it would blow this fortification to atoms." The circle round Mr. Fulton was very soon much enlarged, and before five of the fifteen minutes were out, there were but two or three persons remaining under the gateway The apprehensions of the company amused him, and he took oc

casion to remark, how true it was that fear frequently arose from ignorance.

On the 20th of July, 1807, he blew up with a torpedo, in the harbor of New York, a large hulk brig, which had been prepared for the purpose. This experiment only served to prove to the inhabitants of New York, by ocular demonstration, that the explosion of a torpedo under a vessel's bottom would annihilate her.



The annexed cut represents one of Mr. Fulton's *stationary torpedoes,* which were to be carcasses of powder, having levers attached to the triggers of the locks; numbers of them were to be anchored in the channel through which vessels, to make an attack, must pass. The hostile vessel, in passing over a torpedo, would press the lever and cause an explosion. A is the lever, and B a portion of the rope to which the anchor is attached.

In a letter to the city government of New York, Mr. Fulton says: "You have now seen the effect of the explosion of powder under the bottom of a vessel, and this, I believe, is the best and most simple mode of using it with the greatest effect in marine wars; for a right application of one torpedo will annihilate a ship, nor leave a man to relate the dreadful catastrophe. Thus, should a ship of the line, containing five hundred men, contend with ten good row boats, each with a torpedo and ten men, she would risk total annihilation, while the boats, under cover of the night and with quick movements, would risk only a few men out of the hundred. When two ships of equal force engage, it may be doubtful which will gain the victory; frequently one hundred men are killed, as many wounded, and the ships much injured. But even the vanquished vessels will admit of being repaired, and thus the number of ships of war will not be diminished; but will continue to increase and tyrannize over the rights of neutrals and peaceable nations."

In March, 1810, five thousand dollars were granted by congress for further experiments in submarine explosions, which gave Mr. Fulton another opportunity to exercise his skill. A commission was also appointed to be present and report the results. The sloop of war Argus was prepared for defence against the torpedoes, under the orders of Commodore Rogers, after Mr. Fulton had explained his mode of attack. The defence was so complete, that he found it impracticable to do any thing with his torpedoes as

they were then prepared. Some experiments were tried, however, with his gun-harpoon and cable-cutter; and after several attempts, a fourteen-inch cable was cut off, several feet below the surface of the water. The commissioners appointed to make the report did not exactly agree in sentiments concerning these experiments. The following letter from Mr. Fulton to the secretary of the navy accompanied their report:—

"*Kalorama, (District of Columbia,) February* 1, 1811.

"SIR,—I have the honor to return to you the report of the committee on the torpedo experiments, with that of Commodore Rogers; and the letters of Robert R. Livingston, Morgan Lewis, and Cadwallader D. Colden, on the same subject. The opinions expressed in these papers are, I think, as favorable to this infant art as, under all circumstances, could be expected. It is proved and admitted—

"1st. That the water-proof locks will ignite gunpowder under water.

"2d. It is proved that seventy pounds of powder, exploded under the bottom of a vessel of two hundred tons, will blow her up; hence it is admitted by all the above parties, that if a sufficient quantity of powder (and which, I believe, need not be more than two hundred pounds,) be ignited under the bottom of a first-rate man-of-war, it would instantly destroy her.

"3d. It is proved and admitted by all parties concerned in the experiments, that a gun can be fired under water, and a cable of any size may be cut by that means at any required depth. With these immensely important principles proved and admitted, the question naturally occurs, whether there be within the genius or inventive faculties of man, the means of placing a torpedo under a ship, in defiance of her powers of resistance. He who says there is not, and that consequently torpedoes never can be rendered useful, must of course believe that he has penetrated to the limits of man's inventive powers, and that he has contemplated all the combinations and arrangements which present or future ingenuity can devise to place a torpedo under a ship. There is no man of sound sense, who has the least acquaintance with the difficulties under which all the arts have labored in their infancy, who on calm reflection will be so weak or vain as to presume that he possesses a strength of intellect to foresee all that can be done, not only in infant arts, but in arts now familiar and long established.

"But as it is impossible now to conceive the various modes which may be invented for placing torpedoes under a ship, and as the success is of incalculable importance to our country, there is every

reason to prosecute the experiments with ardor; and we are encouraged to this by a contemplation of the progress of the whole military art, and particularly the attack and defence of fortified places. The celebrated Vauban, after years of experience, aided by a powerful genius, to fortify cities, confessed that it was impossible to make any work so strong by art alone that it could not be taken by the art and exertions of a besieging army, in which the besiegers commence by parallels and zigzags, to approach the rampart of the besieged, and run their mine or subterranean passage under the works to blow them up. During the whole time of their approaches, which is frequently for weeks or months, the besiegers are under as heavy a fire from the besieged, as has or perhaps can be invented; when the explosion makes a breach in the rampart it is defended by all the guns loaded with grape and canister shot, which can be brought to bear upon it: the trench is enfiladed with cannon and small arms. In fact the whole power of the besieged is directed to defend the breach, perhaps not twenty feet wide; yet in defiance of so concentrated a fire, a fire infinitely more destructive than any ship could keep up from her bow, there are hundreds of instances of such breaches having been forced and the works taken. Is it impossible to contemplate the ingenious combinations, the perseverance, the risk and acts of valor of a besieging army, and then believe that there are not ways and means, enterprise and courage, when organized and exercised, to mine through water, which is the work of a few minutes, and blow up a ship, when the risk is not one thousandth part so great as that of storming a breach? I think, sir, this comparative view of the danger in storming a breach, and attacking a ship, proves, that added to three principles before mentioned and admitted, the courage to undertake the attack of a ship with torpedoes must be admitted also.

"I will now consider the progress of the experiments at New York, and the prospect of future improvement which they present:

"First, as to the harpoon, it is admitted that at the distance of 'fifteen feet the harpoon stuck firm.'* Were it improved it should not be fired at a greater distance from the ship than thirty or forty feet, because the sudden jerk on the line might break it off at the torpedo: men in a boat at thirty feet distance from a ship, are in as great danger as when in with her bow and under her guns; thus as the harpoon can be fixed at fifteen feet, I will not at present insist on a greater distance, though I am certain that practice will enable me to fix the harpoons at the distance of forty or

* It entered five inches into oak plank.

more feet if required; but I do insist that organized men, who have courage to storm a breach or to attack a vessel by boarding, have courage to approach within fifteen feet of a ship to fire a harpoon, or even if necessary to drive a spike into her bow; when the ship discharges her bow guns, her bow must be covered with smoke, after which all shot against the boats will be random, particularly if the attack be made in the night; but to protect the men, the torpedo boats may be decked with thick oak plank, and rendered proof against canister and musket-shot. The risk of the men would then be inconsiderable, for while a boat was near in with the bow of the ship, her cannon could not be brought to bear so as to fire round-shot. It is, therefore, a fair conclusion, that, courage added to art, a ship cannot guard herself against a torpedo attack by means of her guns and small-arms only. She must, therefore, have nets, booms, grapnels, &c. &c.

"I will now do justice to the talents of Commodore Rodgers, by stating that the nets, booms, kentledge and grapnels which he arranged round the Argus, made at first sight a formidable appearance against *one torpedo boat and eight bad oarsmen*. I was taken unawares; I had explained to the officers of the navy my means of attack; they did not inform me of their measures of defence; the nets were put down to the ground, otherwise I should have sent the torpedoes under them. In this situation, the means with which I was provided, being imperfect, insignificant, and inadequate to the effect to be produced, I might be compared to what Bartholomew Schwartz, the inventor of gunpowder, would have appeared, had he lived at the time of *Julius Cæsar*, and presented himself before the gates of Rome with a four-pounder, thereby endeavoring to convince the Roman legions that by the means of such machines well organized, he could batter down the walls and take the city: a few catapultas casting arrows and stones upon his men, would have caused them to retreat; a shower of rain might destroy his ill-guarded powder, and the Roman centurions who could not conceive the various modes in which gunpowder has since been used to destroy the then art of war, (as my opponents cannot now see the combinations by which torpedoes may supersede the necessity of ships of war,) would very naturally conclude that it was a useless invention; while the manufacturers of catapultas, bows, arrows, and shields, would be the most vehement against further experiments.

"This, sir, may be conceived a digression; but being on an interesting subject, I have stated this supposed first experiment with a four-pounder as a case in point. Some of the first cannon were made of leather; but if such cannon failed, does it therefore fol

low that gunpowder was useless? Or does it follow, because I was not prepared to put torpedoes through a net the first time it was presented to me, that the defect was in the torpedoes? You, sir, will instantly perceive it was not; but arose from the want of time and experience. I had not one man instructed in the use of the machines, nor had I time to reflect on this particular mode for defending a vessel. I have now, however, had time; and I feel confident that I have discovered a means which will render nets to the ground, booms, kentledge, grapnels, oars with sword-blades through the port-holes, and all such kinds of operations, totally useless. It is as follows:—

"Should an enemy of any force enter one of our ports and put her nets to the ground, let government press from the wharves four or more merchantmen, loaded or in ballast, each of them from three to four hundred tons burden; in the magazine there should be thirty or forty torpedoes, each containing two hundred pounds of powder, and each adjusted to the end of a spar or boom, from forty to sixty feet long, tapering from the butt to the point, where the torpedo, of a conic form, and having on each side a long blade or scythe, should be firmly fixed; let the butt end of the spar be tied so as to act like a swivel under the fore-chains, one on the larboard, the other on the starboard side, and the other end of the spars with the torpedo be hoisted up to the spritsail-yard, and held there until near the scene of action. The expense of thus preparing a ship will be 800 or 1,000 dollars, and each will be as dangerous to an enemy as a fire-ship. The expense of a fire-ship is from 8 to 10,000 dollars, which sum could certainly be expended to greater advantage by arranging torpedo-ships as here proposed, and for the following reasons:—First, 8,000 dollars would pay for arranging eight torpedo-ships, which could be done in a few hours; each with two torpedoes projecting from the bow, which eight ships moving at one time towards the enemy, would divide her fire on eight points, and render it less dangerous to each than in the case of one fire-ship, which would draw on her the whole fire of the vessel attacked.

"Second, the expense of a fire-ship is so great, that an attack is seldom made with more than one; which must be grappled with the enemy, then set on fire and abandoned by her men, who must take to their boat, and expose themselves to the boats and guns of the vessel attacked. Should the fire-ship be grappled to the enemy, still she may not burn so as to communicate the fire: or if to the leeward, she may be cut adrift; at all events, if in port, the men could escape to the shore: therefore, their danger not being great, they would work with more confidence and ardor to extinguish

the flames and save their ship ; yet the danger with which fire-ships impress an enemy makes them respect the ports where they are prepared for action.

" In the year 1776, Commodore Tolbert grappled a fire-ship to a British two-decker in the river Hudson : he set his ship on fire, and returned to shore under a heavy discharge of musketry and cannon, without losing a man. He failed to burn the enemy, but he drove the vessel attacked, and one of equal force, from seven miles above New York down to Staten Island.

" As it does not require so much bravery to make an attack with a torpedo-ship as to grapple a fire-ship to an enemy, the use of fire-ships proves that courage is to be found to attack with those which may be armed with torpedoes. Suppose, then, two torpedo-ships fastened to each other by a chain 80 or 100 feet long, forming a bridle opposite to the fore-chains, in the manner I arrange my floating torpedoes ; then to be sailed or floated down on the tide, the torpedoes let down twenty-two feet under water, one ship steered for the larboard and one for the starboard side of the enemy ; in this manner the chain would cross her cable, before which she must either slip or cut cable and run, or the momentum of the torpedo-ships would sheer round, stern outwards, and press the torpedoes through the nets under her bottom, where instant explosion would be instant death : such an operation gives no time for an enemy to deliberate or exert themselves to push off, or cut torpedo vessels adrift, or to calculate on getting to shore in boats. The tremendous consequence of explosion under a ship deprives common men, such as sailors, of all firmness, and the irresistible danger would also influence the major part of officers : hence this mode of attack is infinitely more to be dreaded than that of fire-ships ; and for these reasons an enemy will not dare to enter our ports to put it to the test. Should any one doubt the practicability of this mode of passing torpedoes through nets and under a vessel, the importance of the object merits the experiment.

" Of the *anchored torpedoes*, I have had the pleasure to show you the improvements I have made on these since the meeting of the committee at New York, to give them stability under water, or to take them up or put them down when necessary : there is a very simple mode to convince any unbeliever of the advantage which this kind of engine will present, and the respect for our harbors which it will create in the mind of an enemy : let me put one under water, and they who do not believe in its effect may put their confidence to the proof by sailing over it.

" A compound engine of this kind will cost from eight hundred to one thousand dollars : three hundred and twenty of them could

be made for the first cost of one ship of 54 guns; of which three hundred and twenty, say one hundred at New York; one hundred, if required, at Boston; one hundred at Charleston; twenty in the Delaware, to be placed in the waters between the forts or batteries and thus four ports could be guarded so as to render it impossible for the enemy's ships to enter either of them, unless they had strength first to take possession of the land and forts, and then time to deliberately search for the torpedoes; yet one ship of 54 guns cannot guard one port against one 74 gun-ship, although her first cost in anchored torpedoes would guard at least three ports against ten ships of 74 guns. In this estimate it may also be stated, that a 54 gun-ship in commission costs the nation one hundred thousand dollars a-year; this, at five per cent., is interest to raise a loan of two millions to build the forts or batteries in barbet, between which the torpedoes should be placed. While I thus compare the expense of torpedoes with that of a ship of 54 guns, I do not mean to object to such ships to protect our coast; but when considered for harbor defence, or aiding forts or batteries to defend harbors, the money can be better expended in torpedoes.

"In the report of the committee it is also admitted that I cut a fourteen-inch cable at the depth of six feet under water, (it was, in fact, twelve feet under the water.) In this experiment, it is true, I was five or six minutes within pistol-shot of the vessel: the reason is, it was only the fourth time a cable-cutting machine was ever tried; with so little experience, I did not attempt to cut at a greater distance: the object at the time being to prove that a cable could be hooked and cut without injuring the machine. New invented instruments must be unskilfully used for a time; but with the practice of only one month and one good boat's crew, I will undertake to cut the cable of a ship at any given depth under water, without approaching nearer to her than eight hundred yards. I will also undertake to place myself at the distance of eight hundred yards from a ship having an unguarded cable, and at that distance I will put an improved cable-cutting machine in the water: I will there abandon it, and it shall go to the cable, cut it off and set the ship adrift, without any further aid on my part than placing it in the water. Such is the unforeseen and incalculable results of mechanical combinations.* It may be said, if one cable be cut and anchor lost, the enemy could put out a second, third, fourth, or fifth anchor and cable; but as a provident government would not undertake to defend a port with one cannon, so there should be in the magazine fifteen or twenty machines for cutting cables,

* This discovery has been produced by my other experiments.

and there should be a marine militia practised in the use of them In such case an enemy could not afford to exchange an anchor and cable, worth five thousand dollars, against three ounces of gunpowder, and at the same time run the risk of being driven on shore in a calm or by a lee-tide; hence, in our calculations on harbor defence, this instrument alone will always be an embarrassing consideration for an enemy.

"It must be admitted that the whole of the experiments at New York were badly executed; but they could not be otherwise. I had not a man practised, nor am I experienced in the use of my own machines. I consequently was necessitated to explain my theory by such imperfect means as I had in my power; yet, under all these disadvantages, I have, to my satisfaction, gained much useful experience, and evidently convinced some of the committee of the great importance of persevering, and particularly with a view to harbor defence. By the experiments I have discovered much of the strength and resources of my opponents; and I am satisfied I can defeat every obstruction which has hitherto been presented: this I hope to prove after some practice. But having witnessed the activity and resources of mind which Commodore Rodgers and Captain Chauncey possess, I look forward to contend with new and difficult combinations which they may produce for defence: in this manner it is probable we shall discover the principal means of defence against torpedoes, and modes of attack with them, until, like the attack and defence of fortified places, the measures to be pursued on each side, in all cases, will become familiar, and a fair calculation may be made on the mode of attacking a ship.

"But, sir, to do this, it is indispensable that I should have twenty or thirty men under my command, to be practised to the use of my engines in my own way. Well as gunnery is understood, no one can hope that young recruits should fire a cannon with skill and effect until they have some months practice. It is therefore, demanding of me to perform a miracle, to apply torpedoes to advantage, break through nets, harpoon ships, and cut cables, with an outfit of one thousand dollars, and not one man practised to assist me. Compare my situation with that of my opponents; men of talents and sound nautical knowledge, working on their own element, the commodore commanding more than four hundred men in a ship of fifty-four guns, which ship, with all her various apparatus as fitted for efficient service, is an engine produced by the combined talents of some thousands of ingenious men, who have directed their attention to the improvement of vessels of war since the invention of gunpowder: thus the commodore,

added to his own talents, has the advantage of the experience and talents of all nautical men who have lived before him; yet he would not be so imprudent as to face an enemy of equal force, if his men were raw recruits unpractised to the guns or working of the ship; and it is to familiarize his men to their duty in each department that he is in a state of constant practice. A succession of experiments on his men, which costs the nation one hundred thousand dollars a year, which experiments, when followed from one to ten or twenty years, at the expense of from one hundred thousand to two millions of dollars, is to enable him to do no more than fight one ship of equal force, in which contest the chances would be equal that he would not take or destroy the enemy: with all this expensive experiment for years of peace to be prepared in case of war, it is not expected that he should contend with a ship of seventy-four guns. But if experiments, which are inconsiderable in their expense compared to that of a fifty-four gun-ship, should prove that attacks with torpedoes can be rendered practicable and efficient, (and every reflection teaches me that they can,) it will be immaterial whether the enemy's vessel be a forty or an eighty gun-ship; two hundred pounds of powder exploded under the bottom of either will produce certain destruction.

"Thus, sir, considering this subject in these various points of view, its infancy, its prospect of success, and, if successful, its immense importance to these states, and to mankind, the small establishment, and inconsiderable sum required to practise and prove its utility, compared with the expense of other nautical establishments which promise only common and imperfect results, I conceive it highly merits a patient and candid succession of experiments; for which purpose I feel the necessity of taking time, that I may have the ensuing summer to practise a few men on nets, and such other obstructions as may be presented; which I hope, sir, will meet with your approbation and that of every friend to science.

"I unite with the committee in opinion that government should not rely on this, or any new invention for defence, until its utility be fully proved. It never has been my wish that such confidence should be placed in torpedoes, until fair experiment had proved their value beyond a doubt.

"I have the honor to be, sir, with great respect,

"Your most obedient,

"ROBERT FULTON."

It is to be feared, that the hints which Fulton has felt for the improvement of his submarine warfare, which he thought so much

of, will be neglected; partly for want of support, and that rare combination of courage, industry, and perseverance which he possessed. We must now, however, revert to an early period of his life, to trace from the beginning the progress of that great improvement in the arts, for which we, and all the world, are so much indebted to him: we mean the practical establishment of navigation by steam. At what time his attention was first directed to this subject, we do not know; but it is ascertained that, in the year 1793, he had matured a plan, in which, even at that early day, he had great confidence.

It is impossible to say how far Mr. Fulton had turned his attention to this subject, and what experiments, or what degree of progress he had made in his plans for steamboat navigation, previously to the year 1801, when he and Chancellor Livingston met at Paris. Among his papers are a variety of drawings, diagrams, and calculations, which evidently relate to the subject, but they are imperfect; most of them are mutilated by the accident before mentioned, and without dates, so that they cannot with certainty be assigned to any particular period. They render it very evident, however, that paddle-wheels, as they are now used in the boats which he built, were among his first conceptions of the means by which steam-vessels might be propelled.

Our limits will not permit us to examine minutely, the pretensions of those who claim to have preceded Mr. Fulton in the application of steam to navigation. That it was not successfully accomplished by any one prior to the execution of his plan, seems to be proved by the acknowledged fact, that though in several instances boats had been made to move by the force of steam, yet not one, either in Europe or America, had ever answered any other purpose than to prove an unsuccessful experiment.

Mr. Fulton, when he conceived a mechanical invention, not only perceived the effect it would produce, but he could ascertain, by calculation, the power his combination would afford, how far it would be adequate to his purpose, and what would be the requisite strength of every part of the machine: and though his numerical calculations did not always prove exact, and required to be corrected by experiments, yet they assured him of general results. Yet he never attempted to put in practice any improvements in mechanics, without having made his calculations, drawn his plans, and executed his models. A view of the progress of his improvements, as they are to be traced from the calculations, drawings, and notes on experiments which he has left, would afford the most useful lessons; and a work which would give them to the world in a proper manner, would be invaluable.

It would be great injustice not to notice with due respect and commendation the enterprises of the late Chancellor Livingston, who had so intimate a connection with Fulton in the progress and establishment of steam navigation. While Mr. Livingston devoted much of his own time and talents to the advancement of science, and the promotion of the public good, he was fond of fostering the discoveries of others. The resources of his ample fortune were afforded with great liberality, whenever he could apply them to the support and encouragement of genius. He entertained very clear conceptions of what would be the great advantages of steamboats, on the large and extensive rivers of the United States. He had applied himself with uncommon perseverance, and at great expense, to constructing vessels and machinery for that kind of navigation. As early as 1798, he believed that he had accomplished his object, and represented to the legislature of New York, that he was possessed of a mode of applying the steam engine to propel a boat on new and advantageous principles ; but that he was deterred from carrying it into effect, by the uncertainty and hazard of a very expensive experiment, unless he could be assured of an exclusive advantage from it, should it be found successful.

The legislature, in March, 1798, passed an act, vesting Mr. Livingston with the exclusive right and privilege of navigating all kinds of boats, which might be propelled by the force of fire or steam, on all the waters within the territory or jurisdiction of the state of New York, for the term of twenty years from the passing of the act; upon condition that he should, within a twelvemonth, build such a boat, the mean of whose progress should not be less than four miles an hour.

Mr. Livingston, immediately after the passing of this act, built a boat of about thirty tons burden, which was propelled by steam; but as she was incompetent to fulfil the condition of the law, she was abandoned.

Soon after he entered into a contract with Fulton, by which it was, among other things, agreed, that a patent should be taken out in the United States in Mr. Fulton's name, which Mr. Livingston well knew could not be done without Mr. Fulton's taking an oath that the improvement was solely his.

We have seen that Mr. Fulton's mind, previous to his return to this country, had long been directed to the project of propelling boats by steam.

Upon Chancellor Livingston's arrival in France, Fulton was induced to revive his thoughts of this invention, by his represen-

tations of the advantages which would be derived from navigation by steam in this country, by his account of the approaches to success which he had made in his experiments, and by the pecuniary support which the chancellor's wealth enabled him to offer. Mr. Fulton began a course of calculations upon the resistance of water, the necessary force to move a body through it, upon the most advantageous form of the body to be moved, and upon the different means of propelling vessels which had been previously attempted; and after a variety of calculations, he rejected the plan proposed of using paddles or oars, likewise that of duck's feet, which open as they are pushed out, and shut as they are drawn in, and also, that of forcing water out at the stern of the vessel; retaining two methods only, as worthy of experiment, namely, endless chains with resisting boards upon them, and the paddle-wheel. The latter was found to be the most promising, and finally adopted, after a number of trials with his models, on a little rivulet which runs through the village of Plombieres, to which place he had retired to pursue his experiments without interruption. This was in the spring of 1802.

It was now determined to build an experimental boat, which was completed in the spring of 1803; but when Mr. Fulton was on the point of making an experiment with her, an accident happened to the boat, the wood-work not having been framed strong enough to bear the weight of the machinery, and the agitation of the river. The accident did the machinery very little injury; but they were obliged to build the boat almost entirely anew. She was completed in July; her length was sixty-six feet, and she was eight feet wide. Early in August, Mr. Fulton addressed a letter to the French National Institute, inviting them to witness a trial of his boat, which was made in their presence, and in the presence of a great multitude of the Parisians. The experiment was entirely satisfactory to Mr. Fulton, though the boat did not move altogether with as much speed as he expected. But he imputed her moving so slowly to the extremely defective fabrication of the machinery, and to imperfections which were to be expected in the first experiment with so complicated a machine, but which he saw might be easily remedied.

Such entire confidence did he acquire from this experiment, that immediately afterwards he wrote to Messrs. Watt and Bolton, of Birmingham, England, ordering certain parts of a steam engine to be made for him, and sent to America. He did not disclose to them for what purpose the engine was intended; but his directions were such as would produce the parts of an engine,

that might be put together within a compass suited for a boat. Mr. Livingston had written to his friends in this country, and through their interference, an act was passed by the legislature of the state of New York, on the 5th of April, 1803, by which the rights and exclusive privileges of navigating all the waters of that state, by vessels propelled by fire or steam, granted to Mr. Livingston by the act of 1798, which we have before mentioned, were extended to Mr. Livingston and Mr. Fulton, for the term of twenty years from the date of the new act. By this law, the time of producing proof of the practicability of propelling by steam a boat of twenty tons capacity, at the rate of four miles an hour, with and against the ordinary current of the Hudson, was extended two years, and by a subsequent law, the time was enlarged to 1807.

Very soon after Mr. Fulton's arrival in New York, he commenced building his first American boat. While she was constructing, he found that her expenses would greatly exceed his calculations. He endeavored to lessen the pressure on his own finances, by offering one third of the right, for a proportionate contribution to the expense. It was generally known that he made this offer, but no one was then willing to afford this aid to his enterprise, although so many, since its success, have been eagerly grasping at its profits.

In the spring of 1807, Fulton's first American boat was launched from the ship-yard of Charles Brown, on the East river. The engine from England was put on board of her, and in August she was completed, and was moved by her machinery from her birthplace to the Jersey shore. Mr. Livingston and Mr. Fulton had invited many of their friends to witness the first trial, among whom were those learned men, Dr. Mitchill and Dr. M'Neven, to whom we are indebted for some account of what passed on this occasion. Nothing could exceed the surprise and admiration of all who witnessed the experiment. The minds of the most incredulous were changed in a few minutes. Before the boat had made the progress of a quarter of a mile, the greatest unbeliever must have been converted. The man who, while he looked on the expensive machine, thanked his stars that he had more wisdom than to waste his money on such idle schemes, changed the expression of his features as the boat moved from the wharf and gained her speed, and his complacent expression gradually stiffened into one of wonder. The jeers of the ignorant, who had neither sense nor feeling enough to suppress their contemptuous ridicule and rude jokes, were silenced for a moment by a vulgar astonishment, which deprived them of the power of utterance, till the triumph of genius extorted

from the incredulous multitude which crowded the shores, shouts and acclamations of congratulation and applause.

The boat had not been long under way, when Fulton ordered her engine to be stopped. Though her performance so far exceeded the expectations of every other person, and no one but himself thought she could be improved, he immediately perceived that there was an error in the construction of her water-wheels. He had their diameters lessened, so that the buckets took less hold of the water, and when they were again put in motion, it was manifest that the alteration had increased the speed of the boat. It may well be said, that the man of genius and knowledge has a sense beyond those which are common to others, or that he sees with different eyes. How many would have gazed on these ill-proportioned wheels, without perceiving that they were imperfect!

This boat, which was called the Clermont, soon after made a trip to Albany. Mr. Fulton gives the following account of this voyage in a letter to his friend, Mr. Barlow. "My steamboat voyage to Albany and back, has turned out rather more favorable than I had calculated. The distance from New York to Albany is one hundred and fifty miles; I ran it up in thirty-two hours, and down in thirty. I had a light breeze against me the whole way, both going and coming, and the voyage has been performed wholly by the power of the steam engine. I overtook many sloops and schooners beating to windward, and parted with them as if they had been at anchor. The power of propelling boats by steam is now fully proved. The morning I left New York, there were not perhaps thirty persons in the city, who believed that the boat would ever move one mile an hour, or be of the least utility; and while we were putting off from the wharf, which was crowded with spectators, I heard a number of sarcastic remarks. This is the way in which ignorant men compliment what they call philosophers and projectors. Having employed much time, money, and zeal, in accomplishing this work, it gives me, as it will you, great pleasure to see it fully answer my expectations. It will give a cheap and quick conveyance to the merchandise on the Mississippi, Missouri, and other great rivers, which are now laying open their treasures to the enterprise of our countrymen; and although the prospect of personal emolument has been some inducement to me, yet I feel infinitely more pleasure in reflecting on the immense advantage that my country will derive from the invention," &c.

Soon after this successful voyage, the Hudson boat was advertised and established as a regular passage-boat between New York and Albany. She, however, in the course of the season, met with several accidents, from the hostility of those engaged in the ordi-

nary navigation of the river, and from defects in her machinery; the greatest of which was, having her water-wheel shafts of cast iron, which was insufficient to sustain the great power applied to them. The wheels also were hung without any support for the outward end of the shaft, which is now supplied by what are called the wheel-guards.

At the session of 1808, a law was passed to prolong the time of the exclusive right to thirty years; it also declared combinations to destroy the boat, or wilful attempts to injure her, public offences, punishable by fine and imprisonment.

Notwithstanding her misfortunes, the boat continued to run as a packet, always loaded with passengers, for the remainder of the summer. In the course of the ensuing winter she was enlarged, and in the spring of 1808, she again commenced running as a packet-boat, and continued it through the season. Several other boats were soon built for the Hudson river, and also for steamboat companies formed in different parts of the United States.

On the 11th of February, 1809, Mr. Fulton took out a patent for his inventions in navigation by steam, and on the 9th of February, 1811, he obtained a second patent for some improvements in his boats and machinery.

It having been found that the laws, granting to Livingston and Fulton exclusive privileges, were insufficient to secure their enjoyment, the legislature of New York, in 1811, passed a supplementary act, giving certain summary remedies against those who should contravene the protecting laws. The act, however, excepts two boats which were then navigating the Hudson, and one which ran on Lake Champlain in opposition to Livingston and Fulton: without these exceptions, the law, as to these boats, would have been *ex post facto*. In respect to these, therefore, the parties were left to the same remedies as before passing the last act. The opposition boats on the Hudson, were at first to have been propelled by a pendulum, which some thought would give a greater power than steam; but on launching their vessel, they found the machinery was not so easily moved as when she was on the stocks. Having found by experiment that a pendulum would not supply the place of steam, and knowing no other way of applying steam than that they saw practised in the Fulton boats, they adopted all their machinery, with some small alterations, with no other view than to give a pretence for claiming to be the inventors of improvements on steamboats.

Messrs. Livingston and Fulton attempted to vindicate their rights, and to stop these boats, by an application to the Circuit Court of the United States for an injunction; but the judge decided that he

had not jurisdiction of the case. They then made application to the Court of Chancery of the state, but the Chancellor, after hearing an argument for several days, refused to grant an injunction. An appeal to the Court of Errors, composed of the Senate of the state, and the five judges of the Supreme Court, unanimously reversed the decision of the Chancellor, and ordered a perpetual injunction; so that the boats could no more be moved with steam, than they could by a pendulum. The merits of the members of this Pendulum Company were contrasted with those of Fulton, by Mr. Emmet, the counsel for the appellants. He described them as " men who never wasted health and life in midnight vigils, and painful study, who never dreamt of science in the broken slumbers of an exhausted mind, and who bestowed on the construction of a steamboat just as much mathematical calculation and philosphical research, as in the purchase of a sack of wheat, or a barrel of ashes."

About the year 1812, two steam ferry-boats were built under the directions of Mr. Fulton for crossing the Hudson river, and one of the same description for the East river. These boats were what are called twin-boats; each of them being two complete hulls united by a deck or bridge. They were sharp at both ends, and moved equally well with either end foremost; so that they crossed and re-crossed without losing any time by turning about. He contrived, with great ingenuity, floating docks for the reception of these boats, and a means by which they are brought to them without a shock.

From the time the first boat was put in motion till the death of Mr. Fulton, the art of navigating by steam was fast advancing to that perfection of which he believed it capable: for some time the boat performed each successive trip with increased speed, and every year improvements were made. The last boat built by him was invariably the best, the most convenient, and the swiftest.

The following anecdote shows the quickness of apprehension, as well as the practical knowledge of Mr. Fulton. It will be remembered by some of our readers, how long, and how successfully, Redheffer had deluded the Pennsylvanians by his perpetual motion. One of these machines was put into operation in New York in 1813. Mr. Fulton was a perfect unbeliever in Redheffer's discovery, and although hundreds were daily paying their dollar tc see the wonder, he could not be prevailed upon to follow the crowd. After a few days, however, he was induced by some of his friends to visit the machine. It was in an isolated house in the suburbs of the city. In a very short time after Mr. Fulton had entered the room in which it was exhibited, he exclaimed, " Why, this is a

crank motion." His ear enabled him to distinguish that the machine was moved by a crank, which always gives an unequal power, and therefore an unequal velocity in the course of each revolution; and a nice and practical ear may perceive that the sound is not uniform. If the machine had been kept in motion by what was its ostensible moving power, it must have had an equable rotary motion, and the sound would have been always the same.

After some little conversation with the show-man, Mr. Fulton did not hesitate to declare that the machine was an imposition, and to tell the gentleman that he was an impostor. Notwithstanding the anger and bluster which these charges excited, he assured the company that the thing was a cheat, and that if they would support him in the attempt, he would detect it at the risk of paying any penalty if he failed. Having obtained the assent of all who were present, he began by knocking away some very thin pieces of lath, which appeared to be no part of the machinery, but to go from the frame of the machine to the wall of the room, merely to keep the corner posts of the machine steady. It was found that a catgut string was led through one of these laths and the frame of the machine, to the head of the upright shaft of a principal wheel; that the catgut was conducted through the wall, and along the floors of the second story to a back cock-loft, at a distance of a number of yards from the room which contained the machine, and there was found the moving power. This was a poor old wretch with an immense beard, and all the appearance of having suffered a long imprisonment; who, when they broke in upon him, was unconscious of what had happened below, and who, while he was seated on a stool, gnawing a crust, was with one hand turning a crank. The proprietor of the perpetual motion soon disappeared. The mob demolished his machine, the destruction of which immediately put a stop to that which had been, for so long a time, and to so much profit, exhibited in Philadelphia. The merits of this exposure will appear more striking, when we consider that many men of ingenuity, learning, and science, had seen the machine: some had written on the subject; not a few of these were his zealous advocates, and others, though they were afraid to admit that he had made a discovery which violated what were believed to be the established laws of nature, appeared also afraid to deny what the incessant motion of his wheels and weights seemed to prove.

Mr. Fulton had enlarged views of the advantages of internal improvements, both as regards commerce, and the stability of the union, by a free intercourse between the states. As early as 1807, he pointed out the practicability of opening a communication

between the great lakes and the Hudson, and in 1811, he was appointed a commissioner to explore the route of an inland navigation, from Hudson river to Lake Erie. His calculations of the advantages of the project are very interesting, and may be found appended to Colden's Life of Fulton.

At the commencement of the year 1814, a number of the citizens of New York, alarmed at the exposed situation of their harbor, had assembled with a view to consider whether some measures might not be taken to aid the government in its protection. This assembly had, in fact, been invited by some knowledge of Mr. Fulton's plans for submarine attack, and of his contemplating other means of defence. They deputed a number of gentlemen to act for them, and these were called the coast and harbor committee. Mr. Fulton exhibited to this committee the model and plans for a vessel of war, to be propelled by steam, capable of carrying a strong battery, with furnaces for red-hot shot, and which, he represented, would move at the rate of four miles an hour. The confidence of the committee in this design was confirmed by the opinions of many of our most distinguished naval commanders, which he had obtained in writing, and exhibited to the committee. They pointed out many advantages which a steam-vessel of war would possess over those with sails only.

The national legislature passed a law in March, 1814, authorizing the president of the United States to cause to be built, equipped, and employed, one or more floating batteries for the defence of the waters of the United States. A sub-committee of five gentlemen was appointed to superintend the building of the proposed vessel, and Mr. Fulton, whose soul indeed animated the whole enterprise, was appointed the engineer. In June, 1814, the keel of this novel and mighty engine was laid, and in October, she was launched from the yard of Adam and Noah Brown, her able and active architects. The scene exhibited on this occasion was magnificent. It happened on one of our bright autumnal days. Multitudes of spectators crowded the surrounding shores, and were seen upon the hills which limited the beautiful prospect. The river and bay were filled with vessels of war, dressed in all their variety of colors, in compliment to the occasion. By May, 1815, her engine was put on board, and she was so far completed as to afford an opportunity of trying her machinery. But, unhappily, before this period, the mind that had conceived and combined it was gone. On the fourth of July, in the same year, the steam-frigate made a passage to the ocean and back, a distance of fifty-three miles, in eight hours and twenty minutes, by the mere force of steam. In September, she made another passage to the sea, and

having at this time the weight of her whole armament on board, she went at the rate of five and a half miles an hour, upon an average, with and against the tide. The superintending committee gave, in their report, a full description of the Fulton the First, the honored name this vessel bore.

We now come to mention the last work in which the active and ingenious mind of Mr. Fulton was engaged. This was a project for the modification of his submarine boat. He presented a model of this vessel to the government, by which it was approved; and under the authority of the executive, he commenced building one; but before the hull was entirely finished, his country had to lament his death, and the mechanics he had employed were incapable of proceeding without him.

During the whole time that Mr. Fulton had thus been devoting his talents to the service of his country, he had been harassed by lawsuits, and controversies with those who were violating his patent rights, or intruding upon his exclusive grants. The state of New Jersey had passed a law which operated against Mr. Fulton, without being of much advantage to those interested in its passage; inasmuch as the laws of New York prevented any but Fulton's boats to approach the city of New York. Its only operation was to stop a boat owned in New York, which had been several years running to New Brunswick, under a license from Messrs. Livingston and Fulton. A bold attempt was therefore made to induce the legislature of the state of New York, to repeal the laws which they had passed for the protection of their exclusive grant to Livingston and Fulton. The committee reported a law which they said might be passed consistently with good faith, honor, and justice! This report being made to the house, it was prevailed upon to be less precipitate than the committee had been. It gave time, which the committee would not do, for Mr. Fulton to be sent for from New York. The senate and assembly in joint session examined witnesses, and heard him and the petitioner, by counsel. The result was, that the legislature refused to repeal the prior law, or to pass any act on the subject. The legislature of the state of New Jersey, also, repealed their law, which left Mr. Fulton in the full enjoyment of his rights. But alas! this enjoyment was of very short duration; for on returning from Trenton, after this last trial, he was exposed on the Hudson, which was very full of ice, for several hours. He had not a constitution to encounter such exposure, and upon his return, found himself much indisposed from the effects of it. He had at that time great anxiety about the steam-frigate, and, after confining himself for a few days, he went to give his superintendence to the artificers employed about her. Forget-

ting his debilitated state of health in the interest he took in what was doing on the frigate, he remained too long exposed, in a bad day, to the weather on her decks. He soon felt the effects of this imprudence. His indisposition returned upon him with such violence as to confine him to his bed. His disorder increased, and on the 24th day of February, 1815, terminated his valuable life.

It was not known that Mr. Fulton's illness was dangerous, till a very short time before his death, which was unexpected by his friends, and still more so by the community. As soon as it was known, all means were taken to testify, publicly, the universal regret at his loss, and respect for his memory. The newspapers that announced the event, had those marks of mourning, which are usual in our country when they notice the death of public characters. The corporation of the city of New York, the different literary institutions and other societies, assembled and passed resolutions expressing their estimation of his worth, and regret at his loss. They also determined to attend his funeral, and that the members should wear badges of mourning for a certain time. As soon as the legislature, which was then in session at Albany, heard of the death of Mr. Fulton, they expressed their participation in the general sentiment, by resolving that the members of both houses should wear mourning for some weeks.

This is the only instance, we believe, of such public testimonials of regret, esteem, and respect being offered on the death of a private citizen, who never held any office, and was only distinguished by his virtues, his genius, and the employment of his talents.

In the year 1806, Mr. Fulton married Miss Harriet Livingston, a daughter of Walter Livingston, Esq., a relative of his enterprising associate, Chancellor Livingston. He left four children; one son, Robert Barlow Fulton, and three daughters.

In conclusion, it may be proper to make a few remarks in relation to the labors of Mr. Fulton. He was not the *original inventor* of steamboats, because many had made them before him; neither was he the *perfector*, because the thing is not yet perfect. What was he then? Why, he was the first to gain the prize; he it was who satisfied the law; and since his boat went from New York to Albany, there has always been a regular succession of steamboats; so that he was the first to bring them into public use, and by his genius and perseverance, he so improved them as to lay a solid foundation for those who came after him to build upon. Professor Renwick has given a concise history of the invention of the steamboat, in his Treatise on Steam Engines; and has taken the right view of the subject, in our opinion, in relation to Mr. Fulton. Al

though there may be those in our own country, as well as in England and France, who are unwilling to give Mr. Fulton his full share of praise, on account of themselves or their relations having been interested in this invention, yet there are others in all these countries who are willing to do him justice. The following is an extract from a memoir published in Paris some years ago; it is from the pen of Mr. Frederick Royou. "I willingly applaud the patriotic sentiment by which M. de Jouffroy desired that the honor of so great an invention should be attributed to a Frenchman. Unhappily, however, it is here a question, much less of an invention, than of the application of a power already known. Besides, Fulton has never claimed the merit of being the inventor in this sense. The application which he made, may be considered as ordinary and common in its nature, because it was pointed out by so many scientific men; but the means of application were necessary, and Fulton has procured them." We extract the following from the English Penny Magazine, which, it is said, has a million of readers. "Fulton, the inventor of the steamboat in North America, which, in a few years, has produced such an astonishing change in that vast country, by connecting together its most distant states, sustained the mortification of not being comprehended by his countrymen. He was, therefore, treated as an idle projector, whose schemes would be useless to the world and ruinous to himself." And again, we find in the same work the following: "We cannot enter into a controversy whether Fulton, or Mr. William Symington, was the *inventor* of the steamboat. What has been said of Arkwright may apply to Fulton:—'The several inventions which his patent embraced, whether they were his or not, would, probably, but for him, have perished with their authors; none of whom, except himself, had the determination and courage to face the multiplied fatigues and dangers that lay in the way of achieving a *practical* exemplification of what they had conceived in their minds.'"

Fulton may be compared with Watt. Both were persevering, and had great inventive powers; and both were fortunate alike in obtaining the confidence and support of patrons, who were generous, and who possessed ample fortunes. In this relation stood Mr Bolton, and Chancellor Livingston.

JACOB PERKINS.

Birth.—Is apprenticed to a goldsmith.—Death of his employer.—Invents a superior method of plating shoe-buckles.—Prosecutes the manufacture of gold beads and shoe-buckles.—Early reputation.—Makes dies for the Massachusetts mint.—Invents the nail-machine.—Through the mismanagement of others, is reduced to poverty.—Harsh treatment by his creditors.—Inventions for the prevention of counterfeiting.—Opinion of public prosecutors concerning them.—Removes to Philadelphia.—Goes out to England.—Proves the compressibility of fluids.—Pleometer.—Bathometer.—Improvements in hardening and softening steel.—Its application to the printing of calicoes and transferring of engravings.—Indenting cylinders.—Watt's steam artillery.—Jonathan Hornblower's steam rocket.—M. Gerard's plan for the defence of Paris.—Perkins' experiments with his steam-gun.—Conclusion.

THIS individual,* who has acquired, probably, more transatlantic fame than any American mechanician now living, is a lineal descendant of the Puritans, and was born in Newburyport, Mass., July, 1766. Early showing a fondness for mechanics, his parents placed him, when thirteen years of age, as an apprentice to a goldsmith.

Three years after, he lost his master: this, however, did not prevent him from continuing in the business. Gold beads and shoe-buckles were then in fashion; and having invented a new and superior method of plating the latter, he prosecuted the manufacture of these articles with considerable profit.

Perkins early acquired a reputation for ingenuity; for, before the adoption of the federal constitution, Massachusetts had a mint for copper coin, and, when he was only about twenty-one, the agent of this establishment hearing of his skill, sent for him to make dies. His success, happily, proved that the confidence was not misplaced. Not long after was invented his famous nail-machine, which cut and headed nails at one operation. This invention was considered very useful, and promised great profits: unfortunately, he was associated with those who had no property, and, by their mismanagement, he not only lost the fruits of several years' hard labor, but all he was worth; and, in addition to these troubles, he was treated by his creditors with unwarrantable harshness.

* American Magazine, Lardner's Cyclopædia, &c. &c.

His next invention appears to have been the preparation of a device for preventing the counterfeiting of bank bills, which had, at that time, become a very serious and extensive evil,—one, too, which the guardians of the public weal almost despaired of remedying. He first made a stamp on the bills, which was of some benefit, for it was seldom imitated. In 1809, the check plate was prepared, which proved the best security then known; and a law was passed in Massachusetts, requiring all the banks to use it. Some years after it was repealed, or was disregarded by the banks, much to the regret of many. Public prosecutors have declared that they never knew a good counterfeit of it.

Perkins resided several years at Philadelphia, when at that time (some thirty years ago) this city was much in advance in the arts of any other place in our country. Some ten or twelve years after, he removed to England. This was, probably, from the hope of finding more able patrons, or a greater opportunity for improvement in his favorite pursuits. It was said at his departure, that he expected to be employed by the English government in preparing plates to prevent the counterfeiting of bills of the Bank of England.

It had ever been maintained by philosophers generally, that water was incapable of compression. Perkins was among the first to doubt the truth of this opinion, and, by his ingenious experiment, has proved beyond a question the falsity of popular opinion. On this principle is his invention of the bathometer, to measure the depth of water: and his pleometer, to mark with precision the rate at which a vessel moves through the water, was invented about the same time. At the announcement of his invention to heat water under an enormous pressure, the public were led, from statements neither sanctioned nor promulgated by the inventor, to indulge in the most extravagant speculations on the power and economy to be derived from this discovery. The disappointment of these absurd expectations was magnified into a reproach against the experimenter, although, in fact, Perkins performed all he promised: and his scheme was only incomplete, from a practical difficulty in getting a suitable material for his generator, sufficiently powerful to withstand the enormous heat and pressure,—an obstacle neither insuperable nor unforeseen.

Among his early inventions, were the improvements in hardening and softening steel at pleasure. This has been highly useful in its results, and has become very well known in connection with roller-press printing from hardened steel plates, now universally used in the printing of calicoes.

A material peculiarity in Mr. Perkins' invention, and one which

does not seem to have been approached by any preceding artist, was the contrivance of what are called *indenting cylinders*. These are rollers two or three inches in diameter, and made of steel, decarbonized so as to be very soft. In this state they are made to roll backward and forward, under a powerful pressure, over the surface of one of the hardened plates, until all the figures, letters, or indentations are communicated with exquisite precision in sharp relief upon the cylinder, which being carefully hardened and tempered, becomes, by this means, fitted to communicate an impression to other plates, by an operation similar to that by which it was originally figured. It will be obvious that one advantage gained by this method must be the entire saving of the labor and expense of recutting, in every case, on different plates, ornaments, borders, emblematical designs, &c.; as these can now be impressed, with little trouble, on any number of plates, or in any part thereof, by the application of the cylinder.

At first sight, the performance of such an operation as the one now alluded to may appear difficult, if not impracticable. Many persons, on its first announcement, were disposed to doubt or deny its possibility altogether. With a proper and powerful apparatus, however, this method of transferring engravings from plates to cylinders, and *vice versa*, is every day performed with facility and success in works exhibiting even very elaborate engraving. By this means the most delicate designs, which would occupy an engraver many months to effect by hand, can be completed in a few days. Of course the cylinders are produced at a much less price, and they may be executed in a very superior manner.

Mr. Perkins has attracted a great deal of attention by his experiments in steam artillery, and in this has far distanced all his predecessors in this mode of warfare. Watt, it appears, once projected something of the kind, but this man of peace did not proceed to much extent with the warlike project. Jonathan Hornblower also constructed what he called a steam rocket; and the French general Chasseloup proposed, some years later, (1805,) a similar plan for the defence of besieged places. M. Gerard, a French officer of engineers, is stated to have carried this idea into practice in 1814, for the purpose of defending Paris at the approach of the allies. In this apparatus the boiler was moved on a carriage, and supplied steam for propelling balls from six gun-barrels, the breeches of which were opened at pleasure; on turning a handle, the six guns received each a ball and the steam at the same time, by a mechanism like what is seen in magazine air-guns. The longest shots were made by turning the handle slowly, and one hundred and eighty balls were thrown in a minute. A wagon at-

tended the machine, to supply fuel and bullets. The capitulation of Paris prevented this novel artillery from being brought into action; and shortly afterwards the apparatus was taken to pieces.

The experiments of Perkins were on a far more daring and extensive scale. The sounds produced by his steam-guns are said to resemble a rapid running fire of musketry, accompanied by a rustling sound or roar that quite deafened the unaccustomed ear. In his experiments before the duke of Wellington and a numerous party of engineer officers, the balls at first were discharged at short intervals, in imitation of artillery firing against an iron target, at the distance of thirty-five yards, and such was the intensity of the propelling force, that they were completely shattered to atoms. In the next trial the balls were fired at a framing of wood, and they actually passed through eleven planks, each one inch thick, of the hardest deal, placed at a distance from each other. Balls, also, which were fired against an iron plate, one quarter of an inch in thickness, passed through it; yet the pressure of steam required to produce this was estimated not much to exceed sixty-five atmospheres, or nine hundred pounds on each square inch.

To demonstrate the rapidity with which musket balls might be thrown, he screwed on to a gun-barrel a tube filled with balls, which falling down by their own gravity into the barrel, were projected one by one with such extraordinary velocity, as to demonstrate that, by means of a succession of tubes filled with balls, fixed in a wheel, a model of which was exhibited, nearly one thousand balls per minute might be discharged. The next experiments were of a more interesting kind. To the gun-barrel was attached a *moveable joint*, a lateral direction was then given to it, and the balls perforated a lineal series of holes in a plank nearly twelve feet long. Thus, had the musket or gun been opposed to a regiment in extended line, it might have been made to shoot down each soldier in succession.

A similar plank was then placed perpendicularly, and in like manner there was a string of shot holes throughout its whole length: and it was thus demonstrated that *steam-guns* could be made to *shoot round a corner!*

Mr. Perkins thus calculated this new mode of warfare:—Suppose two hundred and fifty balls are discharged in a minute by a single-barrelled gun, or fifteen thousand per hour; this, for sixteen hours; would require about fifteen thousand pounds of powder, which, at seventy shillings per hundred weight, would cost five hundred and twenty pounds, (about two thousand three hundred dollars.) But the same number of balls can be thrown in suc-

cession, and in the same time, for the price of five bushels of coal per hour, or about ten or twelve dollars for fifteen hours.

After the experiments Perkins made at Greenwich before Prince Polignac, and some French engineers whom the Duke d'Angouleme had sent to make a report to him concerning them, he received instructions to form a piece of ordnance to throw sixty balls, of four pounds each, in a minute. This he guarantied should be done with the correctness of a rifle musket, and to a proportionate distance. A musket was also attached to the same generator for throwing a stream of lead from the bastion of a fort, and which he engaged to make so far portable as to be capable of being moved from one bastion to another.

Both the French and English engineers before whom these experiments were made condemned the steam-gun as being of no real utility. The practical difficulties of working steam under such an enormous pressure were evident; it being impossible to make it as powerful as gunpowder. Besides, all engines of war should be as simple as possible, for in the heat of action it is rarely that men are found to act with the self-possession necessary in the management of even the simplest machinery, no matter how well drilled they may previously have been in its management.

It is not intended in derogation of the talents and ingenuity of Mr. Perkins, when we say his inventions have not all been as useful in practice as his friends might have wished. The merit, however, awarded to him is sufficient to establish his reputation as one of the most ingenious and philosophical citizens of the union; and his exertions throughout have been of that laudable and meritorious kind, that, even in failure, ought to bring honor

THOMAS BLANCHARD.

Birth.—Early fondness for mechanics.—Anecdote.—At thirteen years of age invents a machine for paring apples.—Assists his brother in the manufacturing of tacks.—Description of the process.—Invents a *counting machine*.—Learns the use of blacksmiths' and carpenters' tools.—Perseverance in perfecting the tack machine.—Final success.—Sells the patent right.—Makes great improvements in the manufacture of muskets.—Anecdote.—Invents the engine for turning irregular forms.—Description.—Anecdote.—Is employed in the national armories in erecting the engines, and making other important improvements. —Congress grants the petition for a renewal of the patent right for the engine.—Interests himself in the subject of railroads.—Invents and makes experiments with a steam-carriage.—Petitions the legislature of Massachusetts.—The report of the committee.—Applies to the legislature of New York.—Interview with Gov. Clinton.—Abandons the project.—Invents a steamboat on a new principle to ascend Enfield Falls.—Makes an excursion up the Connecticut.—Builds a second and superior boat.—Constructs a steamboat on the Alleghany.—Its first voyage.—The Indian chief Cornplanter, and the steamboat.—Encroachments.—Complimentary remarks of Judge Story on the termination of a lawsuit.—Conclusion.

Most of the following materials were obtained by solicitation from the subject of the memoir. We present them to the public with pleasure, as containing some of the leading incidents in the life of an unassuming, yet talented individual, who, by industry and perseverance in his peculiar department, claims an honorable station among the true benefactors of man.

Thomas Blanchard was born in Sutton, Worcester county, Mass., on the 24th of June, 1788. Like most New Englanders, his ancestors were among the early settlers of our country. His father, Mr. Samuel Blanchard, stood high as an agriculturist, a situation solely due to the qualities of industry and economy for which he was noted. Thomas was the fifth of six sons; his fondness for mechanical subjects may be dated back almost to the dawn of life; his first recollections are of cutting up shingles with a knife into all kinds of toys, such as windmills, water-wheels, &c., and when old enough to attend school, he would be seized with an irresistible propensity to steal away from study, and employ the time with his then favorite tools, the knife and gimlet. His advantages for viewing mechanical operations were few, his residence being in a portion of the town where there was not a workshop of any kind, except a country smith's, and even that at some distance. The first time he recollects visiting this place

was with his father, probably at the age of nine or ten. Being obliged to wait during the operation of shoeing their horse, his attention was fully occupied in watching the movements of the smith. What struck him with the greatest wonder and astonishment, was the process of heating and welding two nailrods, and he thought he would give all he possessed to perform such a miraculous operation.

On their road home young Blanchard's mind was full of what he had seen. His thoughts were now raised far above the knife and gimlet, and he was determined, if possible, to imitate the wonder he had just witnessed. Standing near the house was an old weaving shop, containing in the lower part a place for farming tools, and in the attic a parcel of scraps of old iron, from which our young experimenter obtained a full supply. The next, and most troublesome step, was the procuring of fuel; to effect this he determined upon watching the kitchen fire, and, when his mother's back was turned, to wet the burning coals, take them away, and secrete them in a snug corner of the cellar; but finding this a slow, as well as tedious operation, he had recourse, on baking days, to his mother's oven. In a few weeks all was ready, and his parents setting out on a visit to some relations in a neighboring town, gave the long wished-for opportunity. Previous to their departure he was enjoined to perform a certain task: this he commenced, and for a while made rapid progress, but being unable to withstand the temptation, soon abandoned it for the new and more agreeable scheme. Taking the bellows from the kitchen, and collecting the materials from a pile of brick and stone in the yard, he managed to build a very good forge in the weaving shop. An anvil was still wanting, and for a moment he was at loss how to proceed, but happening to think of one of his father's wedges, he obtained it, and driving it into a block, left the square end sufficiently high for the intended purpose; and finally, bringing out his coals from the cellar corner, he was ready to blow up the fire early the next morning. On commencing, he succeeded very well in beating the iron into the required shape; his ambition now was to join two pieces into one, but being ignorant of the "welding heat," in vain exerted his utmost skill; it then occurred to him, if he could only make another visit to the smith, he would be enabled to surmount the difficulty. While devising further plans his parents returned, and his father entering and viewing his son's work, at first feigned to look displeased, but could not refrain from relaxing his countenance at the ludicrous imitation, and after inquiring where the coals came from ended by ordering the youthful Vulcan to take down his forge

and return the materials to their appropriate places; thus ended his first important mechanical experiment.

At the age of thirteen having heard of a machine for paring apples, he was determined to make one, and employed all his leisure in the invention. Although he had received but a mere hint of its operation, it was soon ready for trial, but at first proved unsuccessful: no difficulty was experienced in fixing the apple so as to revolve on turning a crank, yet on applying the knife to the fruit it would run in towards its centre, instead of cutting a thin paring. Not in the least discouraged, he set his "young wits" to work to remedy the deficiency, and the first step was to watch the operation of paring by hand. He observed that the thickness of the shaving was gauged by the thumb of the hand holding the cutter. This led him to see the necessity of fixing a gauge to the knife. Here he learned an important fact, one that may be termed his *first* lesson in the way of invention,—viz. to imitate nature, as in the use of the hand, where machinery is substituted for hand operations. The success of this invention was soon known throughout the neighborhood, and young Blanchard thenceforth became a favorite at all the "*paring bees,*" where he would accomplish more with his machine than half a dozen girls by hand.

The success attending this undertaking gave him new ideas and a greater thirst for invention. Soon after he went to reside with an elder brother, who had a number of persons, mostly boys, to assist him in the business of manufacturing tacks. The operation was to cut them into points from a thin plate of iron, after which they were taken up, one at a time, with the thumb and finger, and held in a tool griping them by the movement of a lever. The lever was put in motion by one foot, while a blow was simultaneously given with a hammer held in the right hand, making a flat head of the large end of the point which projected above the head of the tool. This was the only method then known, and so very slow and irksome, that young Blanchard would often grow tired and disgusted. As a daily task, he was given a certain quantity to manufacture, which number was ascertained by weighing and counting: finding this too much trouble, he was induced to construct a *counting machine.* This was a very ingenious contrivance, consisting of a ratchet wheel moving one tooth every time the jaws of the heading tool moved in the process of making one tack, to which a bell was also attached in such a manner as to give a signal by ringing when the required number was completed.

His brother, on witnessing its operation, forbid him wasting time on such idle projects. He was not, however, of a disposition to

be frustrated in ideas, if he could not execute plans; and even at this early day began to conceive of the design of a machine for cutting and heading tacks. Although his brother would endeavor to discourage him, by saying that it was too small and intricate a process to be performed by machinery, yet he was determined that whenever he became sufficiently skilled, and possessed the means, to prosecute the undertaking.

His father not having any fondness for mechanics, and excelling in his own calling, was resolved to bring up his son Thomas in the same pursuit; but at last, satisfied of its utter impossibility, allowed him to follow that path for which his genius had peculiarly fitted him; not, however, without expressing a truly paternal desire that he should aim at the acquisition of a thorough, practical knowledge of whatever was attempted. The first, and by far most important step, was learning the use of blacksmiths' tools; after which Blanchard became skilled in the different modes of working on wood, turning, &c., which in his subsequent career has given him a decided advantage over others possessing only a theoretical knowledge.

So ardent was he in the pursuit of new projects in the arts, that his early education was greatly neglected, yet the practical knowledge acquired in youth, in some measure supplied the want of literary acquirements; affording, perhaps, in the opinion of some, an additional illustration of the saying of a late philosopher, "that a self-taught man is more likely to produce useful and original ideas, than one who gathers his knowledge from books,"—an axiom so far true, as self-reliance is better than dependence, while a certain medium offers superior advantages.

At the age of eighteen, Blanchard commenced the invention of the tack machine, but was compelled to lay it aside for a time for the want of means. Refunding himself from his other occupations, he recommenced the project, until exhausted resources once more obliged him to abandon it. This course he pursued alternately, for a period of six years, expending all he could raise upon his darling project, carrying the models about from place to place, wherever he could find employment, and throwing the old ones aside as fast as improvements were suggested. Of dauntless perseverance, the advice and earnest entreaties of friends in dissuasion from this apparently hopeless undertaking, but added fuel to the flame. Success at last crowned his efforts, and so complete was the operation, that by placing the iron into the tube or hopper, and applying the moving power, five hundred tacks could be made per minute, with more finished heads and points than were ever made by hand. Such was its perfection, that a

half-ounce weight would balance a thousand. Securing the patent, he sold the right for five thousand dollars to a company who went extensively into the business; a slender compensation considering its importance, but small as it was, it relieved him of embarrassments, and placed him some thousands ahead.

Mr. Blanchard being a practical operator in all branches of machinery, and possessing also economical habits, together with an unwearied perseverance, was enabled to execute his plans at a comparatively small expense. The success of his tack machine inspired him with new confidence, and a greater desire for improvement in the arts.

About this time, attempts were making in the various armories under the patronage of government, to turn musket barrels with an external finish, instead of pursuing the then common and very imperfect mode of reducing them to a uniform thickness by grinding. In accordance with the advice of a friend, possessing great confidence in his skill, Blanchard was induced to invent a machine for turning the cylindrical part of the barrel. There was then remaining about three inches at the breech, requiring to be cut in a different figure, with two flat and oval sides, and, finally, finished by chipping, filing, and grinding. He undertook, with perfect success, the construction of a lathe to turn *the whole of the barrel, from end to end, by the combination of one single, self-directing operation.* To effect this, it was placed in the lathe, and the process commenced at the muzzle, in the ordinary way, turning the cylindrical portion first; but as the cutting instrument approached the breech, the motion was very ingeniously changed into a vibrating one, so as to cut the flats and ovals perfectly parallel with the calibre of the barrel. This was effected by a cam-wheel placed in the arbor of the lathe, and operated by a lever. A knowledge of this important improvement coming to the superintendent of the United States' armory at Springfield, a contract was made with Blanchard to erect one at that establishment.* While the workmen were gathered around to witness its operation, an incident occurred which finally led to the truly wonderful invention for turning irregular forms. One of the men, addressing himself to a companion, says, "Well, John, he has spoiled your job!" "I care not for that," was the reply, "as long as I can get a better." One of the musket-stockers, with a confident shake of the head, then boastingly exclaimed, "that he (Blanchard) could not spoil his, for he could not turn a gun-stock!" This remark struck

* This armory is by far the most extensive in the Union, furnishing employment for three hundred men, who annually manufacture fourteen thousand muskets.

Blanchard very forcibly, and in answer he observed, "I am not so sure of that, but will think of it a while." The idea of turning by machinery such a long irregular form as the stock of a musket, seemed absurd, but he could not banish the subject from his mind. After remaining a few days longer at Springfield, he left for his residence in Worcester county. While passing in a one-horse vehicle, in a state of deep meditation, through the old town of Brimfield, the whole principle of turning irregular forms from a pattern at once burst upon his mind: the idea was so pleasing and forcible, that, like Archimedes of old, he exclaimed aloud, "*I have got it! I have got it!*"—Two countrymen, overhearing this, suddenly started up from the way-side, with countenances expressive of wonder; when one of them, addressing his companion, said, "I guess that man's crazy."

In a short time, Blanchard built a model of this machine, and so exact were its operations that it would perfectly turn a miniature stock.

This machine is represented in the engraving in its most simple form, for turning shoe-lasts; and is so constructed that, from one as a pattern, an exact *facsimile* can be formed from a rough block of wood. Both the pattern and block are fixed on the same axis, and are made to revolve around their common centre, in a swinging lathe, by a pulley and bolt on one end of the axis, as shown in the engraving. On a sliding carriage is attached three posts, through which are fixed pivots, to which are suspended the axles of a *cutting* and a *friction* wheel. The cutting wheel, which is about one foot in diameter, turns on a horizontal axle, and to its periphery is fixed a number of crooked cutters to act like a *gouge* when the wheel is put in motion. This cutting wheel is placed opposite the rough block. The *friction wheel*, which is of the same diameter as the *cutting wheel*, is placed opposite the *pattern*, so as to press against it when in motion. These two wheels are in a line with each other, and are attached to the same carriage. On the axle of the cutting wheel is fixed a pulley,—around which passes a band which puts the cutting wheel in motion by a large drum revolving under it. A crank, or first mover, communicates motion to the drum, which in its turn transfers a rapid motion to the cutting wheel; while a band which passes from a small pulley on the drum-shaft, puts in operation a feeding screw-pulley, which moves the sliding carriage horizontally from left to right. Another pulley on the drum-shaft gives a slow rotary motion both to the pattern and the rough block, in a direction *opposite* to that of the cutting wheel. The friction wheel is turned by the pattern resting against it.

During the revolution, the pattern, being irregular in its surface,

causes the axis to approach and recede from the wheel. Thus it will be seen, as it presents its whole surface to the *friction wheel*, so in like manner the *block* presents its surface to the *cutting wheel*, which being in rapid motion cuts away all that part of the block which is farther from the common centre than the surface of the pattern, and thus forms, from a rough block, an exact resemblance of the model.

To form a facsimile in *reverse*, as a *left* foot shoe-last, from a *right* foot shoe-last, it is only necessary that the pattern should revolve in an opposite direction from the block. A whole sett of lasts, both right and left, can be formed by one pattern, either larger or smaller than the model. This is done by changing the motion and speed of different parts of the machine. To form an object longer than the pattern, the cutting wheel must travel in its right-angle movement faster than the friction wheel, or *vice versa*. To form it larger in *diameter* than the pattern, the axis of the cutting wheel must be kept at a greater distance from the axis of the *block* than the axis of the *pattern* is from the axis of the *friction wheel*. Thus it is plain that an article can be formed by this operation larger or smaller than the model, and still be of the same proportions.

This machine can be applied to turning many different articles with great facility and perfection, such as shoe-lasts, gun-stocks, spokes of wheels, hat-blocks, tackle-blocks, wig-blocks, and any other objects, no matter how irregular their forms, provided their surfaces can be brought in contact with the periphery of the friction wheel.

While at Washington, securing the patent, Blanchard exhibited the machine at the war office, where most of the heads of the different departments had assembled. Among the rest was Commodore R——, then one of the navy commissioners, who, after witnessing its operation and listening to the remarks made, as to the various articles that it could form, jocosely says to the inventor, "Can you turn a *seventy-four?*" "Yes!" was the reply, "if you will furnish a *block*."

The secretary of war was so well satisfied with it, that an agreement was entered into with the inventor to build one immediately for the national armory at Harper's Ferry. He subsequently put one in operation at the Springfield establishment. This opened the way to his other important improvements in the stocking of arms, since universally adopted, consisting in the cutting in the cavity for the lock, barrel, butt-plates, and other parts of the mounting, comprising, together with the turning the stock and barrel, no less than *thirteen* different machines. Mr. Blan-

chard was thus occupied in the employment of government for a period of five years, during which time he had given but little attention to the bringing of the turning machine into use for those other purposes for which it was as well adapted. An opportunity was therefore given to violators, of which they duly took advantage; and more than fifty machines were put in operation, during the first term of the patent, in various parts of the Union, for turning shoe-lasts, handles, spokes, and many other articles, from which he derived no benefit; and all that was received was the government price of nine cents on each musket made at their two armories, at Harper's Ferry and Springfield. On the expiration of the first term of the patent in 1833, he petitioned congress for a renewal, which was granted on the grounds that this was an original machine, standing among the *first American inventions*, while the inventor had not been compensated according to its utility.

In 1825, the public attention was attracted to the subject of railroads and locomotive power. Blanchard having completed his engagements at the armories, built a carriage at Springfield, to travel by steam on common roads. This, it is believed, was the first locomotive put in operation in this country, unless, indeed, the rude contrivance of Evans may be dignified with such an appellation. It was perfectly manageable, could turn corners, and go backwards and forwards with all the facility of a well-trained horse, and on ascending a hill the power could be increased. Blanchard was so well satisfied with it, that he secured a patent. He also built models of railroad turn-outs, and other improvements now in general use. Independent of this, he went so far as to exert himself to raise a company to build railroads, and with this view submitted his plans and improvements to a committee of the Massachusetts legislature, who reported as follows:—

"*Boston, January* 23, 1826.

"The undersigned, having seen the model of a railway and steam-carriage invented by Mr. Thomas Blanchard, of Springfield, in this commonwealth, are of opinion, from their own examinations, and from those of scientific men in this vicinity, that they are valuable improvements, and peculiarly adapted for use in this country: and, as such, are recommended to all the friends of internal improvements.

"JOHN MILLS, "JAMES SAVAGE, "ROBERT RANTOUL, "LEVI FARWELL, "WILLIAM B. CALHOUN,	Joint Committee on Roads and Canals."

Notwithstanding this satisfactory report, capitalists viewed it as a visionary project. Blanchard then applied to the legislature of New York, and, explaining his plans to Governor Clinton, proposed to try the experiment of building a railroad from Albany to Schenectady; but he was of opinion that it was too soon after the completion of the Erie canal. Finding himself before the times, he abandoned the subject.

In 1826, it was determined by some gentlemen residing at Hartford to improve the navigation at the rapids called Enfield Falls, on the Connecticut, between that city and Springfield. These falls are in a rocky, crooked channel of about two miles in length, and are composed of a number of short, shoal rapids, amounting in the whole to about thirty feet descent. The method at that time employed was to navigate them in flat-boats, and even then it was impossible to ascend them without a favorable wind and the assistance of polesmen. Accordingly, a company was formed and the funds raised to build a steamboat for this purpose. Previous to commencing, an agent was sent to examine the different kinds of boats in use on the western waters. On his return, one was built in New York, on the most approved plan, with the wheel under the stern, but, on trial, it proved unsuccessful. The project was then given up as useless, and a canal dug around the falls, at an expense of two hundred thousand dollars, sufficiently large to admit of the passage of a small steamer. In anticipation of its completion, a company in Springfield employed Mr. Blanchard as an agent to build a steamboat. While it was constructing, a freshet damaged the canal so as to cause over a year's delay in its completion. This event caused Blanchard to make the attempt to navigate the falls with their boat, but it proved as fruitless as the experiment of the canal company. This led him to study the subject more fully,—to make experiments as to the best form for a boat and wheels,—to examine the rapids, ascertain the speed of the water, and calculate the power required to ascend them. While thus engaged, he made an important discovery, in which consisted the true secret of his success. This was in placing the wheel at that point astern where the greatest eddy is formed by the filling in of the water after the passage of the boat;—an arrangement by which the paddles give a much more powerful effect than when placed on the sides or immediately astern, as on the western rivers: and for the simple reason that the vacuum created by the passage of the boat causes the current to set in after it with such velocity as to offer a very powerful resistance to the paddles as they strike against the water.

Finding no one willing to assist him, he was determined to

build, at his own expense, a boat on the foregoing plan. While constructing, it was regarded by the public as a visionary scheme and a waste of money. It was made of the best materials, of light draught, and wrought instead of cast iron used in the formation of the engine. By little practice, she ascended the falls with perfect ease, and made her daily trips between Springfield and Hartford as a passage-boat. This was the commencement of a new era in the prosperity of Springfield, for Hartford was no longer the head of steam navigation.

In the autumn of 1828, Blanchard made an excursion with a party in his boat up the Connecticut above Springfield, passing through its fertile and romantic valley for a distance of one hundred and fifty miles. Many of the inhabitants had never seen a steamboat, and consequently flocked to the river by thousands to witness the wonderful power of steam. Having heard of the bursting of boilers, many were at first afraid to approach; but curiosity conquering their fears, they became anxious to see and take a short trip. Its arrival was welcomed by the ringing of bells and the firing of cannon. At one village, so great was the enthusiasm that a line was formed on the river bank, composed of all sexes, who, as she passed, made the welkin ring with their acclamations.

The success of this boat, which was named the Vermont, induced Blanchard to build another and far superior one, (the Massachusetts,) of a larger size, and drawing eighteen inches of water. The wheel and weighty portions of the machinery were supported by two arches of peculiar construction running lengthwise of the vessel, combining great strength with little weight. She was thus enabled to carry two steam engines, one on each side, driving the paddle wheel, with a crank on each end of the wheel shaft, set at right angles with each other. By this arrangement there was not any dead point, or slacking of the wheel, while making a revolution,—a very important point in ascending rapids. The facility of this mode of conveyance caused the travel and transportation to more than double between the two places.

Finding that small rapid rivers could be navigated by this mode of conveyance, Mr. Blanchard soon had many applications from different parts of the union, and in 1830 was employed to build a boat on the Alleghany, to ply between Pittsburg and Olean Point, a distance of three hundred miles; the fall amounting in the whole to six hundred feet, and the river in many places very rapid. This boat was named the Alleghany, and set out on her first trip in the month of May, with thirty passengers and twenty-five tons of freight, passing through many pleasant villages where a steamboat had never been. On reaching the village of the celebrated Indian

chief Cornplanter, an invitation was given him to take an excursion up the river; he at first hesitated, but on being assured that there was no danger, went on board with his family. He witnessed the various parts of the machinery, the engine, paddle wheels, &c., with astonishment, exclaiming, in broken English, "*Great!—great!—great power!*" The Alleghany drawing only eighteen inches of water, was enabled to ascend many of the small streams that empty into the Ohio, and so established the practicability of navigating small and rapid rivers, that this kind of boat has since gone into universal use.

Like all other inventors, Blanchard has experienced his share of wrong from the selfishness of his fellow men. He has secured no less than twenty-four patents for as many different inventions. But a small portion have been of sufficient benefit to pay for the expense of getting them up. Many of them have been used without consent, or even so far as giving him the credit of their invention. While making his first model for turning irregular forms, a neighbor attempted to defraud him of it, by obtaining others to privately watch his movements, who would copy as fast as he progressed. On Blanchard's going to Washington to secure the right, to his great astonishment he found a caveat had been lodged for the same invention only the day previous. Luckily he had taken the precaution, at the time his model was first put into operation, to call two witnesses to view it, and note the date; so he was enabled on trial to sustain his right. Scarcely, however, was this difficulty surmounted before another attempt was made to deprive him of it. A company was about forming in Boston, to put it into operation for turning ships' tackle-blocks, for which right the inventor was to receive several thousand dollars. Two individuals, discovering, on examination, (as they thought,) that the claim was too broad, informed Blanchard of it, at the same time threatening that, unless he would give them one half of what he was about to receive, they would make it public: he rejected these proposals with scorn and indignation. Thereupon an article appeared in the prints, cautioning the public, and stating that the inventor had claimed more than he had invented. This so alarmed those interested, that a stop was put to the formation of the company; he thereupon surrendered up the patent, and took out another.

After he obtained a renewal of his patent by act of congress in 1834, he was determined to prosecute, in order to realize something from his labors. On bringing a suit before Judge Story, of Boston, he was nonsuited through two defects in the patent: one of which was in the date of the patent set forth in the act, and the other in terming the invention a machine,

instead of an engine. On application to congress, although strenuously opposed by the defendants in the former case, the mistake was rectified. Subsequently another suit was commenced against the same violators. The defence set up was,—first, that the plaintiff did not describe his machine so clearly in the specification as to enable a skilful artist to build it; secondly, that the machine was not the invention of the plaintiff; and thirdly, that the claim was for the function, and not for the machine itself. But not any proof being brought to establish this defence, the court overruled all objections, and gave judgment for the plaintiff. His honor Judge Story, on making his remarks, paid the following high compliment to Mr. Blanchard, viz.: "That after much trouble, care, and anxiety, he will be enabled to enjoy the fruits, unmolested, of his inventive genius, of which he had a high opinion; and it afforded him much pleasure in thus being able publicly to express it."

Mr. Blanchard, at the present time, is residing in New York city, where he is engaged in an invention promising to be of superior utility. We trust that success will attend all his future efforts: and may he continue to merit the increased gratitude of his fellow citizens by the productions of his inventive talents.

HENRY ECKFORD.

Birth.—Is placed with an eminent naval constructor at Quebec.—Commences ship-building in New York.—Establishes the reputation of the naval architecture of that city.—Improvements.—Indebtedness of our country to his exertions during the late war.—Verplanck's tribute to his memory.—Builds the steam-ship "Robert Fulton."—Is appointed naval constructor at Brooklyn.—Builds the Ohio.—Resigns.—Is engaged in constructing vessels of war for the various European and some of the South American governments.—Plan for a new organization of the navy.—Unfortunate connection with a stock company.—Honorable acquittal.—Is appointed chief naval constructor of the Turkish empire.—Death.—Character.

We are indebted to the kindness of a friend for the following memoir of one, whose talents and industry evinced in improving the popular arm of our national defence, should render our country proud of ranking him among her adopted children.

Henry Eckford was born at Irvine, (Scotland,) March 12, 1775. At the age of sixteen he was sent out to Canada, and placed under the care of his maternal uncle, Mr. John Black, an eminent naval constructor at Quebec. Here he remained for three or four years, and in 1796, at the age of twenty-one, commenced his labors in New York. His untiring industry and attention to business soon procured for him numerous friends; and the superior style in which his ships were built excited general attention. At that time the vessels constructed at Philadelphia stood highest in the public esteem; but it is scarcely too much to say, that those built by Mr. Eckford soon occupied the first rank, and gradually New York built ships bore away the palm from all competitors. Equally conversant with the theoretical as well as with the practical part of his profession, he never frittered away his own time or the money of his employers in daring experiments, which so often extort applause from the uninformed multitude. He preferred feeling his way cautiously, step by step. Upon the return of one of his vessels from a voyage, by a series of questions he obtained from her commander an accurate estimate of her properties under all the casualties of navigation. This, connected with her form, enabled him to execute his judgment upon the next vessel to be built. In this way he proceeded, successively improving the shape of each, until those constructed by him, or after his models, firmly estab-

lished the character of New York built ships over those of any other port in the union.

It would be impossible, within the limits prescribed by the nature of this work, to point out the various improvements in the shape and rig of all classes of vessels suggested by the fertile mind of Mr. Eckford; and perhaps their technical details would be unintelligible to ordinary readers. It is sufficient to observe, that after his models our vessels gradually dispensed with their large and low stern frames, the details of their rigging underwent extensive changes, and in the important particulars of stability, speed, and capacity, they soon far surpassed their rivals.

Mr. Eckford had married and become identified with the interests of his adopted country when the war broke out between America and England. He entered into contracts with the government to construct vessels on the lakes, and the world witnessed with astonishment a fleet of brigs, sloops of war, frigates, and ships of the line, constructed within an incredibly short space of time. At the present day, we can scarcely appreciate the difficulties and discouragements under which operations on so extended a scale were obliged to be conducted. The country was comparatively wild and uninhabited, the winters long and severe, provisions and men, with the iron-work, tools, rigging, and sails, were to be transported from the sea-coast, the timber was still waving in the forests, and, to crown the whole, the funds provided by the government were in such bad repute, that, to obtain current funds therefrom, Mr. Eckford was obliged to give his personal guarantee.

Under all these embarrassments, he commenced his operations with his accustomed activity and judgment, organized his plans, and offered every inducement to the interests, the pride, and the patriotism of those in his employ to labor to the extent of their ability. Encouraged by his presence and example, they entered upon their labors with enthusiasm, and neither night nor day saw a respite to their toils. The consequences were quickly apparent. A respectable fleet was soon afloat, and our frontier preserved from the invasion of a foe as active and persevering as ourselves. In allusion to these efforts, one of our intelligent citizens, Mr. Verplanck, in a discourse delivered before the Mechanics' Institute, has happily observed, "I cannot forbear from paying a passing tribute to the memory of a townsman and a friend. It is but a few days since that the wealth, talent, and public station of this city were assembled to pay honor to the brave and excellent Commodore Chauncey. Few men could better deserve such honors, either by public service or private worth; but all of us who recollect the events of the struggle for naval superiority on the lakes

during the late war with Great Britain, could not help calling to mind that the courage, the seamanship, and ability of Chauncey would have been exerted in vain, had they not been seconded by the skill, the enterprise, the science, the powers of combination, and the inexhaustible resources of the ship-builder, Henry Eckford."

At the conclusion of the war, his accounts, involving an amount of several millions of dollars, were promptly and honorably settled with the government.

Shortly after this, he constructed a steam-ship, the "Robert Fulton," of a thousand tons, to navigate between New York and New Orleans. Unlike the light and fairy-like models of the present day, which seem only fit for smooth water and summer seas, she was a stout and burdensome vessel, fitted to contend with the storms of the Atlantic, and her performance, even with the disadvantage of an engine of inadequate power, far exceeded every expectation. The sudden death of her owner, in connection with other circumstances, caused her to be sold; and it is no slight commendation of her model, that when she was afterwards rigged into a sailing vessel, she became the fastest and most efficient sloop-of-war (mounting twenty-four guns) in the Brazilian navy. It is to be regretted that the model then proposed by Mr. Eckford for sea steamers has not been followed. The vain attempt to obtain speed, without a corresponding change in the shape of the model, that would enable them to contend successfully with heavy seas, has been attended with disgraceful failures, involving an immense loss of lives.

A strong feeling of professional pride induced Mr. Eckford to accept an invitation from the Secretary of the navy to become naval constructor at Brooklyn. He was desirous of building a line-of-battle ship for the ocean that should serve as a model for future vessels of that class, and in the Ohio, we believe, it is generally conceded such a model has been obtained. Her ports, it is true, have been altered to suit the whim of some ignorant officer, who has thus weakened her frame in order to imitate an English model, and her spars have been curtailed of their due proportions, to gratify a commissioner's fancy; but, under all these disadvantages, she is to remain a model for future constructors. Unfortunately, our marine was then encumbered, as it is now, with a board of commissioners composed of old navy officers, who fancied that because they commanded ships they could build them,—an idea as preposterous as it would have been to have intrusted the naval constructors with their command. Under this sage administration of the affairs of the navy, six ships of the line, costing four

millions of dollars, were constructed; the constructors received their orders from the sages at Washington, and each vessel, as was to have been expected, became worse than the preceding. Two of them are permitted to rot in the mud, a third has been cut down to a frigate possessing no very creditable properties, and the others, if not humanely suffered to rot, will probably follow their example.

The same signal disgrace has fallen upon our sloops of war. Under a mistaken idea of strength and stability, their frames are solid, and in many instances their leeway and headway are nearly balanced. Some of them, we are officially informed, possess every desirable property, except that they are rather difficult to *steer!* Those in the least acquainted with the subject need hardly be informed that this exception, trifling as it seems, is conclusive against the model.

At the head of this board was Commodore John Rodgers, and *his* instructions and *his* orders were to be the basis of Mr. Eckford's operations. These orders, copied, for the most part, out of some exploded work on naval architecture, were wisely disregarded, although their receipt was duly acknowledged; and he has been heard to observe, that when the vessel was completed, he would have challenged the whole board to have examined and pointed out in what particulars their orders had not been implicitly obeyed. Under the orders of the commissioners, he had prepared a model which, after due examination, was graciously approved of. When Mr. Eckford proceeded to lay down the vessel, he thought fit to introduce many important changes, and the only genuine draught of the Ohio is now owned by Mr. Isaac Webb, one of the most intelligent of his pupils. The consequence, however, of these collisions between presuming ignorance and modest worth were soon obvious. Mr. Eckford resigned his commission on the day the Ohio was launched; and shortly after received an intimation, that he would never see her put in commission as long as the members of that board held their seats. This promise, as our readers are aware, was kept for eighteen years.

Shortly after this he engaged extensively in his profession; and so great and extended became his reputation, that he was called upon to construct vessels of war for various European powers, and for some of the republics of South America. Among others, he built and despatched to Columbia and Brazil four 64 gun-ships, of 2000 tons each, in the incredibly short space of eighteen months In these cases his accounts were promptly adjusted, and he re ceived from all parties highly honorable testimonials of his integ rity, punctuality, and good faith. He subsequently received pro

posals to build two frigates for Greece; but as he thought he perceived, on the part of the agents, a disposition to take an unfair advantage of the necessities of that nation, he honorably and humanely declined their tempting propositions. All are aware of the disastrous and (to this country) disgraceful manner in which that business terminated.

Upon the accession of General Jackson to the presidency, he received from him an invitation to furnish him with a plan for a new organization of the navy. This was promptly furnished, and was pronounced by all who read it to be exactly what was required for an efficient and economical administration of the navy. It was not acted upon, although its adoption would have materially advanced the interests of the country. Among other novel propositions, it was recommended to remodel entirely the dockyards. These were to be under the superintendence of superannuated commodores, who, in taking command, would relinquish their rank and make way for more active officers. The constructor at each yard was to be held responsible for the quantity and quality of work done, and only amenable to the chief constructor at Washington. This latter office, he took occasion, however, to say, he could not, under any circumstances, be persuaded to accept. He wished, in short, from what he had himself observed of the extravagance, waste, and delay at our dockyards, to place them on a civil footing, as more consonant to the feelings of the mechanics and the spirit of our institutions.

About this period he determined to prepare and publish a work on naval architecture, for which he had ample materials, and numerous draughts of vessels of almost every class. He had also set aside twenty thousand dollars to establish a professorship of naval architecture in Columbia college, and had already entered into correspondence with an eminent constructor, Mr. Doughty, whom he had intended as the first professor, when a disastrous affair occurred, involving his reputation and his ample fortune. An insurance company, in which he was largely interested, became, in the panic of the day, insolvent, and its creditors ventured, in the madness of the moment, to throw doubts on the hitherto unimpeached character of Mr. Eckford. In this they were aided by a knot of political partisans, to whom his silent, but gradually increasing popularity, (which had, long ere this, placed him in the state legislature,) was gall and wormwood. Notwithstanding he satisfactorily proved that he had lost, by stock, and other advances to save the sinking credit of the company, nearly half a million of dollars, yet his enemies affected to discredit his testimony, upon the ground that such unparalleled sacrifices were too

disinterested to be credible. The termination of the investigation resulted in his complete and honorable acquittal, but the venomed shaft rankled in his kind and gentle breast to the hour of his death. It is no consolation to his numerous friends and relatives to know, that all who joined in this base conspiracy against this pure-minded and well-principled man have since paid the forfeit of their infuriated zeal, by the silent, but withering contempt of their fellow-citizens.

In 1831, he built a sloop-of-war for the Sultan Mahmoud, and was induced to visit Turkey. His fame as a skilful architect had preceded him, and he was shortly afterwards offered the situation of chief naval constructor for the empire. A field worthy of his enterprise seemed open to him. With his characteristic energy he commenced the organization of the navy yard, and laid down the keel of a ship of the line. He had rapidly entered in her construction, and had so far advanced in the favor of the sultan that preparations were in train to create him a Bey of the empire, when his labors were suddenly brought to a close by his lamented death, from inflammation of the bowels, which occurred November 12, 1832, in the fifty-seventh year of his age.

In private life, Eckford was remarkably simple in his manners and habits. Abstemious and temperate, he always possessed unclouded faculties; and his quiet attention and kindness to all under his control enabled him to secure their ready co-operation in any of his plans which required from them willing and prompt exertions. The scrupulous observance of his contracts to the minutest particular was with him a point of honor; and his dealings with his fellow-men bore rather the character of princely munificence than the generosity of a private individual. Throughout life, and amid transactions involving millions, he maintained the same unassuming habits, considering himself but the mere trustee for the benefit of others; and died as he had lived, honored and beloved by all who knew him.

FOREIGN MECHANICS.

JOHN SMEATON.

John Smeaton was born the 28th of May, 1724, at Austhorpe, near Leeds. The strength of his understanding and the originality of his genius appeared at an early age. His playthings, it is said by one long well acquainted with him, were not the playthings of children, but the tools men work with, and he appeared to derive more pleasure from seeing the men in the neighborhood work, and asking them questions, than from any thing else. When not quite six years old, he was seen one day, much to the alarm of his friends, on the top of his father's barn, fixing up something like a windmill. Not long after he attended some men fixing a pump at a neighboring village, and observing them cut off a piece of bored pipe, he was so lucky as to procure it, and actually made with it a working pump that raised water. In his fourteenth and fifteenth years, he made for himself an engine to turn rose-work, and presented his friends with boxes turned in ivory or wood. At the age of eighteen he had acquired by the strength of his genius and indefatigable industry, an extensive set of tools, and the art of working in most of the mechanical trades, without the assistance of any master, and this with an expertness seldom surpassed.

His father was an attorney, and intended to bring up his son to his own profession; but the latter finding, to use his own words, "that the law did not suit the bent of his genius," obtained his parent's consent that he should seek a more congenial employment. Accordingly he came to London, where he established himself as a mathematical instrument maker, and soon became known to the scientific circles by several ingenious inventions; among which were a new kind of magnetic compass, and a machine for measuring a ship's way at sea.

In 1753, he was elected a member of the Royal Society, and contributed several papers to their philosophical transactions. In the succeeding year he visited Holland, travelling mostly on foot

and in passage-boats, to make himself master, with greater ease, of the mechanical contrivances of those countries. A few years after his return he was applied to, to rebuild the Eddystone lighthouse, a structure which has rendered his name so celebrated. To more fully illustrate the difficulties he had to surmount, we give in connection a brief history of the lighthouse.

Eddystone lighthouse is erected on one of the rocks of that name, which lie in the English Channel about fourteen miles S.S.W. from Plymouth. The nearest land to the Eddystone rocks is the point to the west of Plymouth called the Ram Head, from which they are about ten miles almost directly south. As these rocks (called the Eddystone, in all probability, from the whirl or eddy which is occasioned by the waters striking against them) were not very much elevated above the sea at any time, and at high water were quite covered by it, they formed a most dangerous obstacle to navigation, and several vessels were every season lost upon them. Many a gallant ship which had voyaged in safety across the whole breadth of the Atlantic, was shattered to pieces on this hidden source of destruction as it was nearing port, and went down with its crew in sight of their native shores. It was therefore very desirable that the spot should, if possible, be pointed out by a warning light. But the same circumstances which made the Eddystone rocks so formidable to the mariner, rendered the attempt to erect a lighthouse upon them a peculiarly difficult enterprise. The task, however, was at last undertaken by a Mr. Henry Winstanley, of Littlebury in Essex, a gentleman of some property, and not a regularly-bred engineer or architect, but only a person with a natural turn for mechanical invention, and fond of amusing himself with ingenius experiments, and withal was somewhat of an excentric character. In his house at Littlebury, a visiter would enter a room where he saw an old slipper on the floor; he would kick away the slipper, and a figure with the appearance of a being from the other world would start up before him. He would sit down in a chair, and immediately a pair of arms would clasp him around the waist. He would go into an arbor in the garden, by the side of a canal, and straightway he would find himself afloat in the middle of that piece of water, without the power of getting ashore, until a person in the secret had moved certain machinery. Mr. Winstanley also contrived some ingenious water-works.

The fabric erected by this amateur engineer, upon the Eddystone, was of timber, sixty feet high, and was four years in building; during which time the workmen suffered much from bad weather, and were once or twice taken off in a state of starvation, after having been for weeks debarred all intercourse with the land.

Finding that the waves often rose so high as to bury the lantern, Mr. Winstanley, in the fourth year, enlarged the base and added forty feet to the height; and yet in violent weather the sea would seem to fly a hundred feet above the vane; and it was generally said that a six-oared boat might have been directed on the top of a wave through the open gallery of the lighthouse. In November, 1703, some repairs being required, Mr. Winstanley went down to Plymouth to superintend the performance of them. The general opinion was, that the building would not be of long duration; but the builder held different sentiments. As he was about to embark with his workmen, the danger was intimated to him in a friendly manner, and it was remarked that one day or other the lighthouse would certainly overset. To this he replied, that he was so well assured of its stability, "*that he should only wish to be there in the greatest storm that ever blew.*" In this wish he was but too soon gratified; for on the 26th of the month just mentioned, while he was still superintending the repairs, there occurred one of the severest storms within the memory of the oldest inhabitants; being the same which Defoe thought proper to chronicle in a volume under the title of "THE STORM." When the people looked abroad the next morning, not a trace of the Eddystone lighthouse was to be seen. The whole fabric, with its ingenious architect, and many other persons, had perished.

As if to show the necessity of instantly rebuilding it, the Winchelsea, a homeward-bound Virginiaman, almost immediately after, struck upon the rock, and was lost, with most of the crew. It was not, however, till 1706, that a new work was commenced. The second Eddystone lighthouse was built as the private undertaking of a Captain Lovett. The immediate architect was Mr. John Rudyard, a linen draper, who, like Winstanley, seems to have had a taste for mechanical pursuits. The building was in the lower part constructed of alternate courses of granite and oak timber; in the upper part, of timber alone: the whole being cased in timber very carefully jointed. The light-room was sixty-one feet above the rock, and the whole height to the ball at the top was ninety-two. The general form was circular, and there were no projections of any kind, in both of which respects it improved upon the former building, which was heavy cornered, with many superfluous ornaments. During the progress of the work, a French privateer took the men upon the lighthouse, together with their tools, and carried them to France, where the captain, it is said, expected a reward for his exploit. While the captives lay in prison, the transaction reached the ears of Louis XIV. who immediately ordered them to be released, and the captors to be

put into their place; declaring that though he was at war with England, he was not at war with mankind. He accordingly directed the men to be returned to their work with presents, as a compensation for the inconvenience which they had suffered The lighthouse was completed in 1709.

From the simplicity of the figure of this building, and the judgment shown in its construction, it was considered likely, notwithstanding the nature of the materials, to have withstood the effects of the winds and waves for an unlimited period. It was doomed, however, to fall before an accident which had not been calculated upon. At two o'clock on the morning of the 2d of December, 1755, one of the three men who had the charge of it, having gone up to snuff the candles in the lantern, found the place full of smoke, from the midst of which, as soon as he opened the door, a flame burst forth. A spark from some of the twenty-four candles, which were kept constantly burning, had probably ignited the wood-work, or the flakes of soot hanging from the roof. The man instantly alarmed his companions; but being in bed and asleep, it was some time before they arrived to his assistance. In the mean time he did his utmost to effect the extinction of the fire by heaving water up to it (it was burning four yards above him) from a tubful which always stood in the place. The other two, when they came, brought up more water from below; but as they had to go down and return a height of seventy feet for this purpose, their endeavors were of little avail. At last a quantity of the lead on the roof having melted, came down in a torrent upon the head and shoulders of the man who remained above. He was an old man of ninety-four, of the name of Henry Hall, but still full of strength and activity. This accident, together with the rapid increase of the fire, notwithstanding their most desperate exertions, extinguished their last hopes; and making scarcely any further efforts to arrest the progress of the destroying element, they descended before it from room to room, till they came to the lowest floor. Driven from this also, they then sought refuge in a hole or cave on the eastern side of the rock, it being fortunately by this time low water. Meanwhile the conflagration had been observed by some fishermen, who immediately returned to the shore and gave information of it. Boats, of course, were immediately sent out. They arrived at the lighthouse about ten o'clock, and with the utmost difficulty a landing was effected, and the three men, who were by this time almost in a state of stupefaction, were dragged through the water into one of the boats. One of them, as soon as he was brought on shore, as if struck with some panic, took flight, and was never

more heard of. As for old Hall, he was immediately placed under medical care; but although he took his food tolerably well, and seemed for some time likely to recover, he always persisted in saying that the doctors would never bring him round, unless they could remove from his stomach the lead which he maintained had run down his throat when it fell upon him from the roof of the lantern. Nobody could believe that this notion was any thing more than an imagination of the old man; but on the twelfth day after the fire, having been suddenly seized with cold sweats and spasms, he expired; and when his body was opened there was actually found in his stomach, to the coat of which it had partly adhered, a flat oval piece of lead of the weight of seven ounces five drams. An account of this extraordinary case is to be found in the 49th volume of the Philosophical Transactions.

The proprietors, who by this time had become numerous, felt that it was not their interest to lose a moment in setting about the rebuilding of the lighthouse. One of them, a Mr. Weston, in whom the others placed much confidence, made application to Lord Macclesfield, the president of the Royal Society, to recommend to them the person whom he considered most fit to be engaged. His lordship immediately named and most strongly recommended Mr. Smeaton. Once more, therefore, the Eddystone lighthouse was destined to have a self-educated architect for its builder. When it was first proposed that the work should be put into his hands, he was in Northumberland; but he arrived in London on the 23d of February, 1756. On the 22d of March he set out for Plymouth, but, on account of the badness of the roads, did not reach the end of his journey till the 27th. He remained at Plymouth till the 21st of May, in the course of which time he repeatedly visited the rock, and having, with the consent of his employers, determined that the new lighthouse should be of stone, hired workyards and workmen, contracted for the various materials he wanted, and made all the necessary arrangements for beginning and carrying on the work. Every thing being in readiness, and the season sufficiently advanced, on the fifth of August the men were landed on the rock, and immediately began cutting it for the foundation of the building. This part of the work was all that was accomplished that season, in the course of which, however, both the exertions and the perils of the architect and his associates were very great. On one occasion the sloop in which Mr. Smeaton was, with eighteen seamen and laborers, was all but lost in returning from the work.

During this time the belief and expressed opinion of all sorts of persons was that a stone lighthouse would certainly not stand the

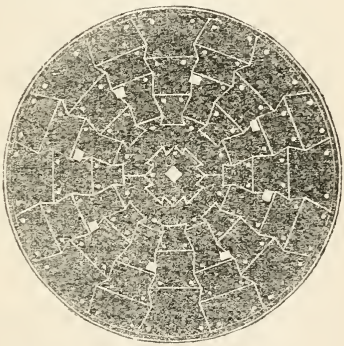
winds and seas to which it would be exposed on the Eddystone However, on the 12th of June, 1757, the first stone was laid.

From this period the work proceeded with great rapidity. On the 26th of August, 1759, all the stonework was completed. On the 9th of October following the building was finished in every part; and on the 16th of the same month the saving light was again streaming from its summit over the waves. Thus the whole undertaking was accomplished within a space of little more than three years, "without the loss of life or limb," says Mr. Smeaton, "to any one concerned in it, or accident by which the work could be said to be materially retarded. During all this time there had been only four hundred and twenty-one days, comprising two thousand six hundred and seventy-four hours, which it had been possible for the men to spend upon the rock; and the whole time which they had been at work there was only one hundred and eleven days ten hours, or scarcely sixteen weeks. Nothing can show more strikingly than this statement the extraordinary difficulties under which the work had to be carried on.

Smeaton spent much time in considering the best method of grafting his work securely on the solid rock, and giving it the form best suited to secure stability; and one of the most interesting parts of his interesting account is, that in which he narrates how he was led to choose the shape which he adopted, by considering the means employed by nature to produce stability in her works. The building is modelled on the trunk of an oak, which spreads out in a sweeping curve near the roots, so as to give breadth and strength to its base, diminishes as it rises, and again swells out as it approaches to the bushy head, to give room for the strong insertion of the principal boughs. The latter is represented by a curved cornice, the effect of which is to throw off the heavy seas, which being suddenly checked, fly up, it is said, from fifty to one hundred feet above the very top of the building, and thus are prevented from striking the lantern, even when they seem entirely to enclose it.

To prepare a fit base for the reception of the column, the shelving rock was cut into six steps, which were filled up with masonry, firmly dovetailed and pinned with oaken trenails to the living stone, so that the upper course presented a level circular surface. The building is faced with Cornish granite, called in the country, moorstone; a material selected on account of its durability and hardness, which bids defiance to the depredations of marine animals, which have been known to do serious injury, by perforating Portland stone when placed under water. The interior is built of Portland stone, which is more easily obtained

in large blocks, and is less expensive in the working. It is an instructive lesson not only to the young engineer, but to all persons, to see the diligence which Smeaton used to ascertain what kind of stone was best fitted to his purposes, and from what materials the firmest and most lasting cement could be obtained. He well knew that in novel and great undertakings no precaution can be deemed superfluous which may contribute to success; and that it is wrong to trust implicitly to common methods, even when experience has shown them to be sufficient in common cases. For the height of twelve feet from the rock the building is solid. Every course of masonry is composed of stones firmly jointed and *dovetailed* into each other, and secured to the course below by *joggles*, or solid plugs of stone, which being let into both, effectually resist the lateral pressure of the waves, which tend to push off the upper from the under course.



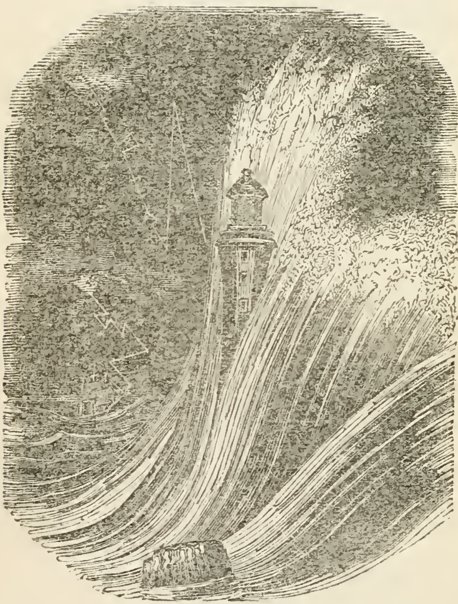
[Horizontal Section of the lower and solid part of the Eddystone Lighthouse; showing the mode in which the courses of stone are *dovetailed* together.]

The interior, which is accessible by a moveable ladder, consists of four rooms, one above the other, surmounted by a glass lantern, in which the lights are placed. The height from the lowest point of the foundation to the floor of the lantern is seventy feet; the height of the lantern is twenty-one feet more. The building has braved, uninjured, the storms of eighty winters, and is likely long to remain a monument almost as elegant, and far more useful than the most splendid column ever raised to commemorate imperial victories. Its erection forms an era in the history of lighthouses, a subject of great importance to a maritime nation. It came perfect from the mind of the artist, and has left nothing to be added or improved. After such an example, no rock can be

considered impracticable: and in the more recent erection of a lighthouse on the dangerous Bell-rock, lying off the coast of Forfarshire, Scotland, which is built exactly on the same model, we see the best proof of the value of an impulse, such as was given to this subject by Smeaton.

Among many other tempests which this structure has endured unshaken, was one of extraordinary fury, which occurred in the beginning of the year 1762. One individual, who was fond of predicting its fate, declared on that occasion, "*that if it stood then, it would stand until the day of judgment!*" On the morning after the storm had spent its chief fury, many anxious observers pointed their glasses to the spot, where they scarcely expected ever to discern it, and a feeling almost of wonder, mixed itself with the joy, thankfulness, and pride of the architect's friends, as they with difficulty descried its form through the still dark and troubled air. It was uninjured even to a pane of glass in the lantern. In a letter from Plymouth, written upon this occasion, the writer says:—"It is now my most steady belief, as well as everybody's here, that its inhabitants are rather more secure in a storm, under the united force of wind and water, than we are in our houses from the former only."

According to the account published by Mr. Smeaton, the lighthouse was attended by three men, who each received a salary of twenty-five pounds a year, with an occasional absence in the summer. At an earlier period there had been only two who had watched alternately four hours; but one being taken ill and dying, the necessity of a third hand became apparent. On the death of his companion, the survivor found himself in an awkward predicament. Being apprehensive if he tumbled the body into the sea, which was the only method he had of disposing of it, he might be charged with murder, he was induced for some time to let the dead body lie, in hopes that the boat might come and relieve him from his embarrassment. A month elapsed before the boat could land, and by that time he was in a state of distress beyond all description, in consequence of the decay of the corpse, which for some time had been in such a state that he could not remove it, however anxious to do so. A less painful result of the employment of only two men is related. On some pique arising between them they forebore to speak to each other, and incredible as it may appear, spent a month together in this wild solitude, without exchanging a word. Another anecdote of the lighthouse may be related. A man who had been a shoemaker being employed to go out as one of the keepers, was on his way to the rock, when the master of the yacht said to him, "How happens it, friend Jacob, that you



EDDYSTONE LIGHTHOUSE IN A STORM.

should choose to become a light-keeper, at scarce ten shillings a week, when, as I am told, you can earn half-a-crown and three shillings a day in making leather hose?" "Why," answered the craftsman, "I go to be a light-keeper, because I don't like *confinement!*" This answer producing a little merriment, he explained himself that he did not like to be confined to work.

Smeaton's wonderful success in this undertaking established his reputation, and his after labors are connected with almost every great work of his time. It would be in vain, however, to enumerate all the projects in which he was consulted, or the schemes which he executed.

The variety and extent of his employments may be best estimated from his Reports, which fill three quarto volumes, and constitute a most interesting and valuable series of treatises on every branch of engineering: as draining, bridge-building, making and improving canals and navigable rivers, planning docks and harbors, the improvement of mill-work, and the application of mechanical improvements to different manufactures. They contain descriptions of his inventions, together with a treatise on mill-work, and some papers which show that he was fond of astronomy and practically skilled in it.

His health began to decline about 1785, and he endeavored to withdraw from business, and devote his attention to publishing an account of his inventions and works; for, as he often said, "he thought he could not render so much service to his country as by doing that." He succeeded in bringing out his elaborate account of the Eddystone lighthouse, published in 1791. But he found it impossible to withdraw entirely from business; and it appears that over-exertion and anxiety did actually bring on an attack of paralysis to which his family was constitutionally liable. He was taken ill at his residence at Austhorpe, in September, 1792, and died October 28th, in the sixty-ninth year of his age. He had long looked to this disease as the probable termination of his life, and felt some anxiety concerning the likelihood of outliving his faculties, and in his own words of "lingering over the dregs after the spirit had evaporated." This calamity was spared him: in the interval between his first attack and death his mind was unclouded, and he continued to take his usual interest in the occupations of the domestic circle. Sometimes only, he would complain with a smile of his slowness of apprehension, and say, "It cannot be otherwise: the shadow must lengthen as the sun goes down."

His character was marked by undeviating uprightness, industry, and moderation in the pursuit of riches. His gains might have been far larger, but he relinquished more than one appointment

which brought in a considerable income, to devote his attention to other objects which he had more at heart; and he declined magnificent offers from Catherine II. of Russia, who would have bought his services at any price. His industry was unwearied, and the distribution of his hours and employments strictly laid down by rule. In his family and by his friends he was singularly beloved, though his demeanor sometimes appeared harsh to strangers. A brief, but very interesting and affectionate account of him, written by his daughter, is prefixed to his Reports, from which many of the anecdotes here related have been derived.

The rule of his practice, and one which he adhered to with the most undeviating firmness, was never to trust to deductions drawn from a theory in cases where he could have any opportunity of a trial. As he got older, he used to say, "Care not about any theory at all. A man of experience does not require it. In my intercourse with mankind, I have always found those who would *thrust theory into practical matters, at bottom to be men of no judgment and pure quacks*. In my own practice, almost every successive case would have required an independent theory of its own; theory and quackery go hand in hand."

Smeaton appeared to Playfair as a man of excellent understanding, improved more by very extensive experience and observation, than by learning or education. He had much the appearance of an honest and worthy man; his manners not much polished; his conversation most instructive in any thing relating to mechanics, or the business of an engineer; but in conversation the embarrassment of his language was very great.

EDWARD SOMERSET,

MARQUIS OF WORCESTER,

INVENTOR OF THE STEAM ENGINE.

Edward Somerset, Marquis of Worcester, was born at Ragland Castle, near Monmouth, about the year 1597. Very little is preserved respecting the history of this ingenious nobleman, and our notice must be therefore necessarily brief. During the civil war between Charles the First and the parliament, Worcester, being then a young man, espoused the cause of his king, and after the

surprise and capture of Monmouth by the parliamentary army, at the head of a small party of volunteers, he scaled a redoubt, passed the ditch, put the guard to death, dashed sword in hand into the place, retook it, and made the garrison prisoners. This brave and daring achievement established his reputation for courage and enterprise.

A short time after he was sent into Ireland, to negotiate for bringing over a large body of Irish to the royal cause, but not succeeding, his conduct was artfully misrepresented by those envious of his fame. Popular feeling thus setting against him, Worcester considered it prudent to seek safety from its virulence by coming over to France. To fill up the cup of his misfortunes, Ragland Castle, the home of his childhood, was besieged; and after being defended by his father with the courage of an old Roman, it surrendered at last upon honorable conditions; these however were perfidiously broken, and the venerable old man survived the catastrophe but a few months. The ruin of the family now seemed complete, the seat of its splendor was destroyed, its majestic woods were consigned to the axe, its domain alienated, and its chief an exile.

During the ascendancy of parliament Worcester resided abroad. When again in an unfortunate hour accepting a commission from the heir to the throne, (afterwards Charles II.,) he proceeded to London for the purpose of procuring private intelligence and supplies of money, of which his master stood in the greatest need. He was, however, speedily discovered and committed a close prisoner to the Tower, where he remained in captivity several years. While in confinement, his time was beguiled by those mechanical amusements which ever formed his greatest source of happiness. Here, according to tradition, his attention was first drawn to the amazing force of steam, by observing the rising of the lid of a vessel employed in cooking in his chamber, and from this circumstance he projected that wonderful machine which has thrown around his name so bright a radiance.

The return of the king from France, and his ascendancy to the throne; gave Worcester once more a home, but now in his old age he was doomed to feel all the miseries of hope deferred. The ear of the king was closed by the intrigues of enemies, or by ingratitude; and the man who had spent the fortune of a prince in the cause, was left, in its final triumph, nearly in a state of poverty, oppressed with debt and without resources. On his enlargement from prison, neither the ruin of his own fortune nor the increasing infirmities of age had any effect in damping the ardor of his enthusiasm,—when other minds would have sunk under the neglect

and distress of his situation, his appeared to grow more elastic as trouble increased.

In the year 1655, Worcester wrote his famous Century (hundred) of Inventions. This work contained but little more than a mere definition of what the inventions were destined to perform. His object in committing them to writing appears to have been for the purpose of reference, when he should be in a situation to carry them out; hence the descriptions, although well enough for his own purpose, are in general too indefinite for comprehension. The novelty of the greater number of the hundred propositions or descriptions of which this volume consists, and the wonderful nature of others, cast an air of improbability over the whole: the author was charged with describing many things which he wished were invented, rather than machines which he had actually constructed. But these charges are scarcely worth noticing, as they are brought by literary men, who from their pursuits are incapable of judging of the feasibility of mechanical projects. Yet this collection of descriptions bears internal marks of being in many cases what it professes, drawn up from actual trials of machines in existence. On an attentive examination of the general scope of his inventions, the greater number will appear to have been suggested by the wants of his accidental situation, and a small portion by those of his station. To a statesman employed in highly confidential negotiations, the secrecy of his correspondence would be of the greatest importance,—to a traveller the security of his locks,—a soldier is mainly interested in his arms, at times in scaling a fortification, or transmitting intelligence in the dark,—and the projector of a water company could not fail of laying his ingenuity under contribution in devising a mode of raising water above its own level. These classes comprises the greater part of his inventions, and if he did not carry them *all* into execution, it does not seem to have been so much his fault, as that of the age in which he lived; but the doubt is greatly lessened by considering his perseverance and his means. For thirty-five years he employed an ingenious mechanic under his own eye, whose time was doubtless spent on the inventions described in the Century. In the machine for raising water by steam, it would be almost impossible to describe effects so clearly as he has done, without actually looking at a machine in operation. His description (although very obscure) is contained in the sixty-eighth proposition, in connection with the ninty-ninth and one hundredth of the "Century," and evidently proves that to him belongs the honor of inventing the *first steam engine*.

A few years before his death he succeeded in procuring an act of parliament to be passed enabling himself and heirs, for ninety

years thereafter, to receive the sole benefit, profit, and advantage resulting from the use of this machine. But this was of little avail, for like men of a similar genius in more humble life, he was oppressed by poverty and want of encouragement; and the desire of being useful to his country in the way which his experience pointed out as of all others the most effective, gained strength as his offers of service were rejected. Although at every period of life he seems to have been deeply impressed with the feeling that progress was never made in any thing by supine wishes and dilatory efforts, unremitting perseverance were in his case to be of no use in stemming the tide of adverse fortune. His wishes were *written in sand;* and in the prosecution of philanthropic projects, he was fated not only to experience the neglect of the public, but the ingratitude of friends, without being convinced of the hopelessness of the attempt at introducing improvements beyond the comprehension and spirit of the age. As long as hope survived, and that ceased not until he "was summoned by the angel of death," he continued to prefer with vigor his claims to public attention and patronage.

Worcester died in poverty, on the 4th of April, 1667. After his death, his wife, in endeavoring to introduce the "water commanding (steam) engine" into general use, not only lay under the imputation of "insanity" for thus persisting in carrying it forward, but was expostulated with by a Romish priest as being "*instigated by the devil!*"

From a manuscript volume containing the travels of Cosmo de Medicis, grand duke of Tuscany, first printed in 1818, it appears that about thirty years after the death of Worcester, he actually saw his steam engine in use pumping up water in London.

JAMES FERGUSON.

Among self-educated men, there are few who claim more of our admiration than the celebrated James Ferguson. If ever any one was literally his own instructor in the very elements of knowledge, it was he. Acquisitions that have scarcely in any other case, and probably never by one so young, been made without the assistance either of books or a living teacher, were the discoveries of his solitary and almost illiterate boyhood. There are few more interesting narratives in any language than the account

which Ferguson himself has given of his early history. He was born in the year 1710, a few miles from the village of Keith, in Banffshire; his parents, as he tells us, being in the humblest condition of life, (for his father was merely a day-laborer,) but religious and honest. It was his father's practice to teach his children himself to read and write, as they successively reached what he deemed the proper age; but James was too impatient to wait till his regular turn came. While his father was teaching one of his elder brothers, James was secretly occupied in listening to what was going on; and, as soon as he was left alone, used to get hold of the book, and work hard in endeavoring to master the lesson which he had thus heard gone over. Being ashamed, as he says, to let his father know what he was about, he was wont to apply to an old woman who lived in a neighboring cottage to solve his difficulties. In this way he actually learned to read tolerably well before his father had any suspicion that he knew his letters. His father at last, very much to his surprise, detected him one day reading by himself, and thus found out his secret.

When he was about seven or eight years of age, a simple incident occurred which seems to have given his mind its first bias to what became afterwards its favorite kind of pursuit—viz. mechanics. The roof of the cottage having partly fallen in, his father, in order to raise it again, applied to it a beam, resting on a prop in the manner of a lever, and was thus enabled, with comparative ease, to produce what seemed to his son quite a stupendous effect. The circumstance set our young philosopher thinking; and after a while it struck him that his father, in using the beam, had applied his strength to its extremity, and this, he immediately concluded, was probably an important circumstance in the matter. He proceeded to verify his notion by experiment; and having made several levers, which he called bars, soon not only found that he was right in his conjecture as to the importance of applying the moving force at the point most distant from the fulcrum, but discovered the rule or law of the machine, namely, that the effect of any form or weight made to bear upon it is always exactly proportioned to the distance of the point on which it rests from the fulcrum. "I then," says he, "thought that it was a great pity that, by means of this bar, a weight could be raised but a very little way. On this I soon imagined that, by pulling round a wheel, the weight might be raised to any height, by tying a rope to the weight, and winding the rope round the axle of the wheel, and that the power gained must be just as great as the wheel was broader than the axle was thick; and found it to be exactly so, by hanging one weight to a rope put round the wheel, and ano

ther to the rope that coiled round the axle." The child had thus, it will be observed, actually discovered two of the most important elementary truths in mechanics—the lever, and the wheel and axle; he afterwards hit upon others; and, all the while, he had not only possessed neither book nor teacher to assist him, but was without any other tools than a simple turning lathe of his father's, and a little knife wherewith to fashion his blocks and wheels, and the other contrivances he needed for his experiments. After having made his discoveries, however, he next, he tells us, proceeded to write an account of them; thinking this little work, which contained sketches of the different machines drawn with a pen, to be the first treatise ever composed of the sort. When, some time after, a gentleman showed him the whole in a printed book, although he found that he had been anticipated in his inventions, he was much pleased, as he was well entitled to be, on thus perceiving that his unaided genius had already carried him so far into what was acknowledged to be the region of true philosophy.

He spent some of his early years as a keeper of sheep, in the employment of a small farmer in the neighborhood of his native place. He was sent to this occupation, he tells us, as being of weak body; and while his flock was feeding around him, he used to busy himself in making models of mills, spinning-wheels, &c., during the day, and in studying the stars at night, like his predecessors of Chaldea. When a little older, he went into the service of another farmer, a respectable man called James Glashan, whose name well deserves to be remembered. After the labors of the day, young Ferguson used to go at night to the fields, with a blanket about him and a lighted candle, and there, laying himself down on his back, pursued for long hours his observations on the heavenly bodies. "I used to stretch," says he, "a thread, with small beads on it, at arms' length, between my eye and the stars; sliding the beads upon it, till they hid such and such stars from my eye, in order to take their apparent distances from one another; and then laying the thread down on a paper, I marked the stars thereon by the beads." "My master," he adds, "at first laughed at me; but when I explained my meaning to him, he encouraged me to go on; and, that I might make fair copies in the daytime of what I had done in the night, he often worked for me himself. I shall always have a respect for the memory of that man." Having been employed by his master to carry a message to Mr. Gilchrist, the minister of Keith, he took with him the drawings he had been making, and showed them to that gentleman Mr. Gilchrist upon this put a map into his hands, and having sup

plied him with compasses, ruler, pens, ink, and paper, desired him to take it home with him, and bring back a copy of it. "For this pleasant employment," says he, "my master gave me more time than I could reasonably expect; and often took the threshing-flail out of my hands, and worked himself, while I sat by him in the barn, busy with my compasses, ruler, and pen." This is a beautiful, we may well say, and even a touching picture—the good man so generously appreciating the worth of knowledge and genius, that, although the master, he voluntarily exchanges situations with his servant, and insists upon doing the work that must be done, himself, in order that the latter may give his more precious talents to the more appropriate vocation. We know not that there is on record an act of homage to science and learning more honorable to the author.

Having finished his map, Ferguson carried it to Mr. Gilchrist's, and there he met Mr. Grant of Achoynamey, who offered to take him into the house, and make his butler give him lessons. "I told Squire Grant," says he, "that I should rejoice to be at his house, as soon as the time was expired for which I was engaged with my present master. He very politely offered to put one in my place, but this I declined." When the period in question arrived, accordingly, he went to Mr. Grant's, being now in his twentieth year. Here he found both a good friend and a very extraordinary man, in Cantley the butler, who had first fixed his attention by a sun-dial which he happened to be engaged in painting on the village school-house, as Ferguson was passing along the road on his second visit to Mr. Gilchrist. Dialling, however, was only one of the many accomplishments of this learned butler, who, Ferguson assures us, was profoundly conversant both with arithmetic and mathematics, played on every known musical instrument except the harp, understood Latin, French, and Greek, and could let blood and prescribe for diseases. These multifarious attainments he owed, we are told, entirely to himself and to nature; on which account Ferguson designates him "God Almighty's scholar."

From this person Ferguson received instructions in Decimal Fractions and Algebra, having already made himself master of Vulgar Arithmetic by the assistance of books. Just as he was about, however, to begin Geometry, Cantley left his place for another in the establishment of the Earl of Fife, and his pupil thereupon determined to return home to his father.

Cantley, on parting with him, had made him a present of a copy of Gordon's Geographical Grammar. The book contains a description of an artificial globe, which is not, however, illustrated

by any figure. Nevertheless, "from this description," says Ferguson, "I made a globe in three weeks at my father's, having turned the ball thereof out of a piece of wood; which ball I covered with paper, and delineated a map of the world upon it; made the meridian ring and horizon of wood, covered them with paper, and graduated them; and was happy to find that by my globe (which was the first I ever saw) I could solve the problems."

For some time after this, he was very unfortunate. Finding that it would not do to remain idle at home, he engaged in the service of a miller in the neighborhood, who, feeling probably that he could trust to the honesty and capacity of his servant, soon began to spend all his own time in the alehouse, and to leave poor Ferguson at home, not only with every thing to do, but with very frequently nothing to eat. A little oatmeal, mixed with cold water, was often, he tells us, all he was allowed. Yet in this situation he remained a year, and then returned to his father's, very much the weaker for his fasting. His next master was a Dr. Young, who having induced him to enter his service by a promise to instruct him in medicine, not only broke his engagement as to this point, but used him in other respects so tyrannically, that, although engaged for half a year, he found he could not remain beyond the first quarter, at the expiration of which, accordingly, he came away without receiving any wages, having "wrought the last fortnight," says he, "as much as possible with one hand and arm, when I could not lift the other from my side." This was in consequence of a severe hurt he had received, which the doctor was too busy to look to, and by which he was confined to his bed for two months after his return home.

Reduced as he was, however, by exhaustion and actual pain, he could not be idle. "In order," says he, "to amuse myself in this low state, I made a wooden clock, the frame of which was also of wood, and it kept time pretty well. The bell on which the hammer struck the hours was the neck of a broken bottle." A short time after this, when he had recovered his health, he gave a still more extraordinary proof of his ingenuity, and the fertility of his resources for mechanical invention, by actually constructing a time-piece or watch, moved by a spring. But we must allow him to give the history of this matter in his own words.

"Having then," he says, "no idea how any time-piece could go but by weight and line, I wondered how a watch could go in all positions; and was sorry that I had never thought of asking Mr. Cantley, who could very easily have informed me. But happening one day to see a gentleman ride by my father's house, (which was close by a public road,) I asked him what o'clock it then was? He

looked at his watch and told me. As he did that with so much good-nature, I begged of him to show me the inside of his watch; and though he was an entire stranger, he immediately opened the watch, and put it into my hands. I saw the spring box, with part of the chain round it; and asked him what it was that made the box turn round? He told me that it was turned round by a steel spring within it. Having then never seen any other spring than that of my father's gun-lock, I asked how a spring within a box could turn the box so often round as to wind all the chain upon it? He answered, that the spring was long and thin; that one end of it was fastened to the axis of the box, and the other end to the inside of the box; that the axis was fixed, and the box was loose upon it. I told him that I did not yet thoroughly understand the matter. 'Well, my lad,' says he, 'take a long, thin piece of whalebone; hold one end of it fast between your finger and thumb, and wind it round your finger; it will then endeavor to unwind itself; and if you fix the other end of it to the inside of a small hoop, and leave it to itself, it will turn the hoop round and round, and wind up a thread tied to the outside of the hoop. I thanked the gentleman, and told him that I understood the thing very well. I then tried to make a watch with wooden wheels, and made the spring of whalebone; but found that I could not make the wheel go when the balance was put on, because the teeth of the wheels were rather too weak to bear the force of a spring sufficient to move the balance; although the wheels would run fast enough when the balance was taken off. I enclosed the whole in a wooden case, very little bigger than a breakfast teacup; but a clumsy neighbor one day looking at my watch, happened to let it fall, and turning hastily about to pick it up, set his foot upon it, and crushed it all to pieces; which so provoked my father, that he was almost ready to beat the man, and discouraged me so much that I never attempted to make such another machine again, especially as I was thoroughly convinced that I could never make one that would be of any real use."

What a vivid picture is this of an ingenious mind thirsting for knowledge! and who is there, too, that does not envy the pleasure that must have been felt by the courteous and intelligent stranger by whom the young mechanician was carried over his first great difficulty, if he ever chanced to learn how greatly his unknown questioner had profited from their brief interview! That stranger might probably have read the above narrative, as given to the world by Ferguson, after the talents which this little incident probably contributed to develop, had raised him from his obscurity to a distinguished place among the philosophers of his age; and if he did

know this, he must have felt that encouragement in well-doing which a benevolent man may always gather, either from the positive effects of acts of kindness upon others, or their influence upon his own heart. Civility, charity, generosity, may sometimes meet an ill return, but one person *must* be benefited by their exercise; the kind heart has its own abundant reward, whatever be the gratitude of others. The case of Ferguson shows that the seed does not always fall on stony ground. It may appear somewhat absurd to dwell upon the benefit of a slight civility which cost, at most, but a few minutes of attention; but it is really important that those who are easy in the world—who have all the advantages of wealth and knowledge at their command—should feel of how much value is the slightest encouragement and assistance to those who are toiling up the steep of emulation. Too often "the scoff of pride" is superadded to the "bar of poverty;" and thus it is that many a one of the best talents and the most generous feelings

"Has sunk into the grave unpitied and unknown,"

because the wealthy and powerful have never understood the value of a helping hand to him who is struggling with fortune.

Ferguson's attention having been thus turned to the mechanism of time-pieces, he now began to do a little business in the neighborhood as a cleaner of clocks, by which he made some money. He was invited also to take up his residence in the house of Sir James Dunbar, of Durn, to whom he seems to have made himself useful by various little services for which his ingenuity fitted him. Among other things he converted two round stones upon the gateway, into a pair of stationary globes, by painting a map of the earth upon one, and a map of the heavens upon the other. "The poles of the painted globes," he informs us, "stood towards the poles of the heavens; on each the twenty-four hours were placed around the equinoctial, so as to show the time of the day when the sun shone out, by the boundary where the half of the globe at any time enlightened by the sun was parted from the other half in the shade; the enlightened parts of the terrestrial globe answering to the like enlightened parts of the earth at all times. So that, whenever the sun shone on the globe, one might see to what places the sun was then rising, to what places it was setting, and all the places where it was then day or night throughout the earth." Having been introduced to Sir James's sister, Lady Dipple, he was induced at her suggestion to attempt the drawing of patterns for ladies' dresses, in which he soon became quite an adept. "On this," says he, "I was sent for by other ladies in the country, and began to think myself growing very rich by the money I got by such draw-

ings; out of which I had the pleasure of occasionally supplying the wants of my poor father." He still continued, however, his astronomical studies, making observations on the stars, as usual, with his beaded threads, and delineating on paper the apparent paths of the planets as thus ascertained. So excited would he become while thus engaged, that he often conceived, he says, that he saw the ecliptic lying like a broad highway across the firmament, and the planets making their way in "paths like the narrow ruts made by cart wheels, sometimes on one side of a plane road, and sometimes on the other, crossing the road at small angles, but never going far from either side of it."

He now began also to copy pictures and prints with pen and ink; and having gone to reside with Mr. Baird, of Auchmeddan, Lady Dipple's son-in-law, where he enjoyed access to a tolerably well-stocked library, he made his first attempt at taking likenesses from the life, in a portrait which he drew of that gentleman; "and I found," says he, "it was much easier to draw from the life than from any picture whatever, as nature was more striking than any imitation of it." His success in this new profession struck his country patrons as so remarkable, that they determined upon carrying him to Edinburgh, in order that he might be regularly instructed in those parts of the art of which he was still ignorant, lady Dipple liberally agreeing to allow him to live in her house for two years. But when he came to that city he could find no painter who would consent to take him as an apprentice without a premium—a circumstance which his sanguine friends had not counted upon. In this extremity, not knowing what to do, he was advised, by the Reverend Dr. Keith, to trust to his own genius, and to commence the practice of his intended profession without waiting for any other instruction than what he had already received from nature. It was certainly a bold counsel; but Ferguson, having in truth no other resource, followed it, and succeeded beyond his most sanguine expectations, in a very short time making so much money as to enable him not only to defray his own expenses, but to gratify his kind heart by contributing largely to the support of his now aged parents. He followed this business for twenty-six years.

Yet he does not appear to have ever given his heart to painting, and notwithstanding his success, he even made various attempts to escape from it as a profession altogether. When he had been only about two years in Edinburgh, he was seized with so violent a passion for the study, or at least the practice, of medicine, that he actually returned to his father's, carrying with him a quantity of pills, plasters, and other preparations, with the intention of setting

up as the Æsculapius of the village. But it would not do. Of those who took his medicines very few paid him for them, and still fewer, he acknowledges, were benefited by them. So he applied again to his pencil; but, instead of returning immediately to Edinburgh, fixed his residence for a few months at Inverness. Here he employed his leisure in pursuing his old and favorite study of astronomy; and having discovered by himself the cause of eclipses, drew up a scheme for showing the motions and places of the sun and moon in the ecliptic, on each day of the year, perpetually. This he transmitted to the celebrated Maclaurin, who found it to be very nearly correct, and was so much pleased with it, that he had it engraved. It sold very well, and Ferguson was induced once more to return to Edinburgh. He had now a zealous patron in Maclaurin, and one extremely disposed to assist him in his philosophical studies. One day Ferguson having asked the Professor to show him his Orrery, the latter immediately complied with his request, in so far as to exhibit to him the outward movements of the machine, but would not venture to open it in order to get at the wheelwork, which he had never himself inspected, being afraid that he should not be able to put it to rights again if he should chance to displace any part of it. Ferguson, however, had seen enough to set his ingenious and contriving mind to work; and in a short time he succeeded in finishing an Orrery of his own, and had the honour of reading a lecture on it to Maclaurin's pupils. He some time after made another of ivory, (his first had been of wood;) and in the course of his life he constructed, he tells us, six more, all unlike each other.

His mind was now becoming every day more attached to philosophical pursuits; and quite tired, as he says, of drawing pictures, in which he never strove to excel, he resolved to go to London, in the hope of finding employment as a teacher of mechanics and astronomy. Having written out a proof of a new astronomical truth which had occured to him, namely, that the moon must move always in a path concave to the sun, he showed his proposition and its demonstration to Mr. Folks, the President of the Royal Society, who thereupon took him the same evening to the meeting of that learned body. This had the effect of bringing him immediately into notice. He soon after published his first work, "A Dissertation on the Phenomena of the Harvest Moon," with the description of a new Orrery, having only four wheels. Of this work he says, with his characteristic modesty, "Having never had a grammatical education, nor time to study the rules of just composition, I acknowledge that I was afraid to put it to the press; and for the same cause, I ought to have the same fears

still." It was, however, well received by the public; and its ingenious author afterwards followed it up by various other productions, most of which became very popular. In 1748 he began to give public lectures on his favorite subjects, which were numerously and fashionably attended, his late Majesty George III., who was then a boy, being occasionally among his auditors. He had till now continued to work at his old profession of a portrait painter: but about this time he at last bade it a final farewell, having secured another, and, in his estimation, a much more agreeable means of providing a subsistence for himself and his family. Soon after the accession of George III., a pension of fifty pounds per annum was bestowed upon him from the privy purse. In 1763 he was elected a Fellow of the Royal Society; the usual fees being remitted, as had been done in the cases of Newton and Thomas Simpson. He died in 1776, having for many years enjoyed a distinguished reputation both at home and abroad; for several of his works had been translated into foreign languages, and were admired throughout Europe for the simplicity and ingenuity of their elucidations. Of his dialogues on Astronomy, Madame de Genlis says, "This book is written with so much clearness, that a child of ten years old may understand it perfectly from one end to the other."

The faculties of distinct apprehension and luminous exposition belonged, indeed, to Ferguson in a pre-eminent degree. He doubtless owed his superiority here in a great measure to the peculiar manner in which he had been obliged to acquire his knowledge. Nothing that he had learned had been set him as a task. He had applied himself to whatever subject of study engaged his attention, simply from the desire and with the view of understanding it. All that he knew, therefore, he knew thoroughly, and not by rote merely, as many things are learned by those who have no higher object than to master the task of the day. On the other hand, as has often happened in the case of self-educated men, the want of a regular director of his studies had left him ignorant of many departments of knowledge in which, had he been introduced to them, he was probably admirably adapted to distinguish himself, and from which he might have drawn, at all events, the most valuable assistance in the prosecution of his favorite investigations. Thus, familiar as he was with the phenomena of astronomy and the practical parts of mechanics, and admirable as was his ingenuity in mechanical invention, he knew nothing, or next to nothing, either of abstract mathematics or of the higher parts of algebra. He remained, in this way, to the end of his life, rather a clever empiric, to use the term in its original and more honorable signification, as meaning a practical and experimenting philosopher,

than a man of science. This was more peculiarly the sort of peril to which self-educated men were exposed in Ferguson's day, when books of any kind were comparatively scarce, and good elementary works scarcely existed on any subject. Much has since been done, and is now doing, to supply that great desideratum; and even already, in many departments, the man who can merely read is provided with the means of instructing himself both at little expense, and with a facility and completeness such as a century, or even half a century ago, were altogether out of the question. Not a little, however, still remains to be accomplished before the good work can be considered as finished; nor, indeed, is it the nature of it ever to be finished, seeing that, even if we should have perfectly arranged and systematized all our present knowledge, time must be constantly adding to our possessions here, and opening new worlds for philosophy to explore and conquer.

SAMUEL CROMPTON.

Samuel Crompton was born on the 3d of December, 1753, at Firwood, in Lancashire, where his father held a farm of small extent; and according to the custom of those days, employed a portion of his time in carding, spinning, and weaving. Hall-in-the-wood, a picturesque cottage near Bolton, became the residence of the family during the son's infancy, and the memorable scenes of his juvenile inventions. His father died when he was very young. The care of his education devolved on his mother, a pious woman, who lived in a retired manner, and imparted her own sincere and contemplative turn of mind to her son. In all his dealings through life, Samuel was strictly honest, patient, and humane.

When about sixteen years of age, he learned to spin upon a jenny of Hargrave's make, and occasionally wove what he had spun. Being dissatisfied with the quality of his yarn, he began to consider how it might be improved, and was thus naturally led to the construction of his novel spinning-machine. He commenced this task when twenty-one years of age, and devoted five years to its execution. He possessed only such simple tools as his little earnings at the jenny and the loom enabled him to procure, and proceeded but slowly with the construction of his *mule*, but still in a progressive manner highly creditable to his dexterity and perseverance.

He often said, what annoyed him most was that he was not allowed to employ his little invention by himself in his garret; for, as he got a better price for his yarn than his neighbors, he was naturally supposed to have mounted some superior mechanism, and hence became an object of the prying curiosity of the country people for miles around; many of whom climbed up at the windows to see him at his work. He erected a screen in order to obstruct their view;—but he continued to be so incommoded by crowds of visiters, that he resolved at last to get rid of the vexatious mystery by disclosing the whole contrivance before a number of gentlemen, who chose to subscribe a guinea apiece for the inspection In this way he collected about £50, and hence was enabled to construct another and similar machine upon a better and larger plan. The first contained no more than from thirty to forty spindles.

The art of spinning with Crompton's machine, soon became widely known among work people of all descriptions, from the higher wages which it procured above other artisans, such as shoe-makers, joiners, hatters, &c; many of whom were thereby induced to change their employment and become mule spinners. Hence it happened among this motley gang, that if any thing went amiss with their machine, each of them endeavored to supply the deficiency with some expedient borrowed from his former trade;—the *smith* introduced a piece of *iron*,—the *shoemaker* had recourse to *leather*,—the *hatter* to *felt*, &c. &c. whereby valuable suggestions were obtained.

When the mule first became known it was called the *Hall-in-the-wood-wheel*, from the place where it was invented, and shortly after, the *Muslin-wheel*, from its making yarn sufficiently fine for the manufacture of muslin;—but it ultimately received the name of *mule*, from combining the principles of the jenny invented by Hargraves and the water frame of Arkwright:

> "The force of *genius* could no farther go,
> To make a *third* he *joined the other two*."

Being of a retiring and unambitious disposition, and having made no effort to secure by a patent the exclusive enjoyment of his invention, it became public property, and was turned to advantage by more pushing manufacturers.

About the year 1802, Mr. Kennedy and Mr. Lee of Manchester set on foot a subscription for him, whereby they obtained a sufficient capital for the increase of his small manufactory. As a weaver also he displayed great ingenuity, and erected several looms, for the fancy work of that town. Being fond of music, he built himself an organ, with which he entertained his leisure hours

in his cottage. Though his means were slender, he was such a master of domestic economy, as to be always in easy circumstances. In 1812, he made a survey of all the cotton districts in England, Scotland, and Ireland, and obtained an estimate of the number of spindles at work upon his mule principle—then amounting to between four and five millions, and in 1829 to about seven. On his return, he laid the result of his inquiries before his generous friends, Messrs. Kennedy and Lee, with a suggestion, that parliament might possibly grant him some recompense for the national advantages derived from his invention. A memorial was accordingly drawn up, in furtherance of which, some of the most prominent manufacturers in the kingdom, to whom his merits were made known, took a lively interest. He went himself to London with the memorial, and had the satisfaction to see a bill through parliament, for a grant to him of five thousand pounds.

Mr. Crompton was now anxious to place his sons in business, and fixed upon that of bleaching; but the unfavorable state of the times,—the inexperience and mismanagement of his sons,—a bad situation, and a misunderstanding with his landlord, which occasioned a tedious lawsuit, conspired in a short time to put an end to this establishment. His sons then dispersed, and he and his daughter were reduced to poverty. His friends had recourse to a second subscription, to purchase a life annuity for him, which produced £63, per annum. The amount raised for this purpose was collected in small sums, from one to ten pounds, some of which were contributed by the Swiss and French spinners, who acknowledged his merits, and pitied his misfortunes. At the same time his portrait was engraved for his benefit, and a few impressions were disposed of;—he enjoyed this small annuity only two years. He died January 26, 1827, leaving his daughter, his affectionate housekeeper, in poverty.

Mr. Crompton was fortunate in one respect, namely, in having met with a friend like Mr. Kennedy, who had the heart to befriend merit and the talent to commemorate it.

WILLIAM EDWARDS.

William Edwards was born in 1719, in the parish of Eglwysilan, in Glamorganshire. He lost his father, who was a farmer, when he was only two years old; but his mother continued to

hold the farm, and was in this manner enabled to bring up her family, consisting of two other sons and a daughter, beside William, who was the youngest. Her other sons, indeed, were soon old enough to take the chief part of her charge off her hands. William, in the mean time, was taught, as he grew up, to read and write Welsh; and this was all the education he seems to have received. When about the age of fifteen, he first began to employ himself in repairing the stone fences on the farm; and in this humble species of masonry he soon acquired uncommon expertness. The excellent work he made, and the despatch with which he got through it, at last attracted the notice of the neighboring farmers; and they advised his brothers to keep him at this business, and to let him employ his skill, when wanted, on other farms as well as their own. After this he was for some time constantly engaged; and he regularly added his earnings to the common stock of the family.

Hitherto the only sort of building he had practised, or indeed had seen practised, was merely with stones without mortar. But at length it happened that some masons came to the parish to erect a shed for shoeing horses near a smith's shop. By William the operation of these architects were contemplated with the liveliest interest, and he used to stand by them for hours while they were at work, taking note of every movement they made. A circumstance that at once struck him was, that they used a different description of hammer from what he had been accustomed to employ; and, perceiving its superiority, he immediately got one of the same kind made for himself. With this he found he could build his walls both a good deal faster and more neatly than he had been wont to do. But it was not long after he had, for the first time in his life, had an opportunity of seeing how houses were erected, that he undertook to build one himself. It was a workshop for a neighbor; and he performed his task in such a manner as obtained him great applause. Very soon after this he was employed to erect a mill, by which he still farther increased his reputation as an able and ingenious workman. Mr. Malkin, to whose work on the Scenery, &c., of South Wales, we are indebted for these particulars of Edwards's early life, as well as for the materials of the sequel of our sketch, says, that it was while building this mill that the self-taught architect became acquainted with the principle of the arch.

After this achievement, Edwards was accounted the best workman in that part of the country; and being highly esteemed for his integrity and fidelity to his engagements, as well as for his skill, he had as much employment in his line of a common builder,

as he could undertake. In his twenty-seventh year, however, he was induced to engage in an enterprise of a much more difficult and important character than any thing he had hitherto attempted.

Through his native parish, in which he still continued to reside, flowed the river called the Taff, which, following a southward course, flows at last into the estuary of the Severn. It was proposed to throw a bridge over this river at a particular spot in the parish of Eglwysilan, where it crossed the line of an intended road; but to this design difficulties of a somewhat formidable nature presented themselves, owing both to the great breadth of the water, and the frequent swellings to which it was subject. Mountains covered with wood rose to a considerable height from both its banks; which first attracted and detained every approaching cloud, and then sent down its collected discharge in torrents into the river. Edwards, however, undertook the task of constructing the proposed bridge, though it was the first work of the kind in which he ever had engaged. Accordingly, in the year 1746, he set to work; and in due time completed a very light and elegant bridge of three arches, which, notwithstanding that it was the work of both an entirely self-taught and an equally untravelled artist, was acknowledged to be superior to any thing of the kind in Wales. So far his success had been as perfect as could have been desired. But his undertaking was far from being yet finished. He had, both through himself and his friends, given security that the work should stand for seven years; and for the first two years and a half of this term all went on well. There then occurred a flood of extraordinary magnitude; not only the torrents came down from the mountains in their accustomed channels, but they brought along with them trees of the largest size, which they had torn up by the roots; and these, detained as they floated along by the middle piers of the new bridge, formed a dam there, the waters accumulated behind which at length burst from their confinement and swept away the whole structure. This was no light misfortune in every way to poor Edwards; but he did not suffer himself to be disheartened by it, and immediately proceeded, as his contract bound him to do, to the erection of another bridge, in the room of the one that had been destroyed. He now determined, however, to adopt a very magnificent idea—to span the whole width of the river, namely, by a single arch of the unexampled magnitude of one hundred and forty feet from pier to pier. He finished the erection of this stupendous arch in 1751, and had only to add the parapets, when he was doomed once more to behold his bridge sink into the water over which he had raised it, the extraordinary weight of the masonry having forced up the key

stones, and, of course, at once deprived the arch of what sustained its equipoise. Heavy as was this second disappointment to the hopes of the young architect, it did not shake his courage any more than the former had done. The reconstruction of his bridge for the third time was immediately begun with unabated spirit and confidence. Still determined to adhere to his last plan of a single arch, he had now thought of an ingenious contrivance for diminishing the enormous weight which had formerly forced the keystone out of its place. In each of the large masses of masonry called the haunches of the bridge, being the parts immediately above the two extremities of the arch, he opened three cylindrical holes, which not only relieved the central part of the structure from all over-pressure, but greatly improved its general appearance in point of lightness and elegance. The bridge, with this improvement, was finished in 1755, having occupied the architect about nine years in all; and it has stood ever since.

This bridge over the Taff—commonly called the *New Bridge*, and by the Welsh *Pont y Pridd*,—was, at the time of its erection, the largest stone arch known to exist in the world. Before its erection, the Rialto at Venice, the span of which was only ninety-eight feet, was entitled, as Mr. Malkin remarks, to this distinction among bridges; unless, indeed, we are to include the famous aqueduct-bridge at Alcantara, near Lisbon, consisting in all of thirty-five arches, the eighth of which is rather more than a hundred and eight feet in width, and two hundred and twenty-seven in height. The bridge at Alcantara was finished in 1732. Since the erection of the bridge over the Taff, several other stone arches of extraordinary dimensions have been built both in Great Britain and in France; such, for instance, as the five composing the splendid Pont de Neuilly over the Seine, near Paris, the span of each of which is a hundred and twenty-eight feet—the central arch of the bridge over the same river at Mantes, which is of the same dimensions—the Island Bridge, as it is called, over the Liffey, near Dublin, which is a single arch of a hundred and six feet in width—the bridge over the Tees, at Winston, in Yorkshire, which is also a single arch of a hundred and eight feet nine inches wide, and which was built in 1762 by John Johnson, a common mason, at a cost of only five hundred pounds—and the nine elliptical arches, each of a hundred and twenty feet span, forming the magnificent Waterloo bridge, over the Thames at London. But no one of these great works rivals in respect of dimensions the arch constructed by Edwards. The bridge over the Taff, we may add, rises to the height of thirty-five feet above the water, and is the segment of a circle of a hundred and seventy feet in diameter.

Buttressed as it is at each extremity by lofty mountains, while the water flows in full tide beneath it, its aspect, as it is seen rising into the air, may well be conceived to be particularly striking and grand.

This bridge, which is looked upon as a wonder to this day, spread the fame of Edwards over all the country. He afterwards built many other bridges in South Wales, several of which consisted also of single arches of considerable width, although in no case approaching to that of the arch over the Taff. One which he erected over the Tawy, near Swansea, had a span of eighty feet—another at Llandovery, in Carmarthenshire, was eighty-four feet wide—and a third, Wychbree bridge, over the Tawy, was of the width of ninety-five feet. All the bridges which Edwards built after his first attempt have their arches formed of segments of much larger circles than he ventured to try in that case; and the roads over them are consequently much flatter,—a convenience which amply compensates for their inferiority in point of imposing appearance. He found his way to this improvement entirely by his own experience and sagacity; as indeed he may be said to have done to all the knowledge he possessed in his art. Even his principles of common masonry, he used himself to declare, he had learned chiefly from his studies among the ruins of an old Gothic castle in his native parish. In bridge building, the three objects which he always strove to attain in the highest possible degree were, first, durability; secondly, freedom for the passage of the water under the bridge; and lastly, ease of traffic over it.

In commencing architect, Edwards did not abandon the business of his forefathers. He was likewise a farmer to the end of his life. Nay, such was his unwearied activity, that, not satisfied with his week-day labors in these two capacities, he also officiated on Sundays as pastor to an Independent congregation, having been regularly ordained to that office when he was about thirty years of age, and holding it till his death. He accepted the usual salary from his congregation, considering it right that they should support their minister; but, instead of putting the money into his own pocket, he returned it all, and often much more, in charity to the poor. He always preached in Welsh, although early in life he had also made himself acquainted with the English language, having embraced the opportunity of acquiring it under the tuition of a blind old schoolmaster in whose house he once lodged for a short time while doing some work at the county town of Cardiff. He is said to have shown all his characteristic assiduity of application in this effort, and to have made a correspondingly rapid progress.

This ingenious and worthy man died in 1789, in the seventieth

year of his age, leaving a family of six children, of whom his eldest son David became also an eminent architect and bridge-builder, although he had had no other instruction in his profession than what his father had given him.

RICHARD ARKWRIGHT.

We now propose to give, in the memoir of the celebrated Richard Arkwright, some account of an individual, whose rise from a very humble origin to affluence and distinction was the result of his persevering attention to the improvement of the machinery employed in one of the most important branches of manufactures, and whose name is intimately connected with the recent history of the commercial greatness of his native country. This illustrious individual, persecuted and calumniated as nearly all the signal benefactors of corrupt humanity have ever been, was raised up by providence from an obscure rank in life to vindicate the natural equality of man.

Arkwright was born on the 23d of December, 1732, at Preston, in Lancashire. His parents were very poor, and he was the youngest of a family of thirteen children; so that we may suppose the school education he received, if he ever was at school at all, was extremely limited. Indeed, but little learning would probably be deemed necessary for the profession to which he was bred,—that of a barber. This business he continued to follow till he was nearly thirty years of age; and this first period of his history is of course obscure enough. About the year 1760, however, or soon after, he gave up shaving, and commenced business as an itinerant dealer in hair, collecting the commodity by travelling up and down the country, and then, after he had dressed it, selling it again to the wig-makers, with whom he very soon acquired the character of keeping a better article than any of his rivals in the same trade. He had obtained possession, too, we are told, of a secret method of dyeing the hair, by which he doubtless contrived to augment his profits; and perhaps, in his accidental acquaintance with this little piece of chemistry, we may find the germ of that sensibility he soon began to manifest to the value of new and unpublished inventions in the arts, and of his passion for patent rights and the pleasures of monopoly.

It would appear that his first effort in mechanics, as has hap-

pened in the case of many other ingenious men, was an attempt to discover the perpetual motion. It was in inquiring after a person to make him some wheels for a project of this kind, that in the latter part of the year 1767, he got acquainted with a clockmaker of the name of Kay, then residing at Warrington, with whom it is certain that he remained for a considerable time after closely connected. From this moment we may date his entrance upon a new career.

The manufacture of cotton cloths was introduced into Great Britain only towards the end of the seventeenth century; although stuffs, improperly called Manchester cottons, had been fabricated nearly three centuries before, which, however, were made entirely of wool. It is generally thought that the first attempt at the manufacture of cotton goods in Europe did not take place till the end of the fifteenth century, when the art was introduced into Italy. Before this, the only cottons known had been imported from the East Indies.

The English cottons, for many years after the introduction of the manufacture, had only the weft of cotton; the warp, or longitudinal threads of the cloth, being of linen. It was conceived to be impracticable to spin the cotton with a sufficiently hard twist to make it serviceable for this latter purpose. Although occasionally exported, too, in small quantities, the manufactured goods were chiefly consumed at home. It was not till about the year 1760 that any considerable demand for them arose abroad.

But about this time the exportation of cottons, both to the continent and to America, began to be carried on on a larger scale, and the manufacture of course received a corresponding impulse. The thread had hitherto been spun entirely, as it still continues to be in India, by the tedious process of the distaff and spindle, the spinner drawing out only a single thread at a time. But as the demand for the manufactured article continued to increase, a greater and greater scarcity of weft was experienced, till, at last, although there were 50,000 spindles constantly at work in Lancashire alone, each occupying an individual spinner, they were found quite insufficient to supply the quantity of thread required. The weavers generally, in those days, had the weft they used spun for them by the females of their family; and now "those weavers," says Mr. Guest, in his History of the Cotton Manufacture, "whose families could not furnish the necessary supply of weft, had their spinning done by their neighbors, and were obliged to pay more for the spinning than the price allowed by their masters; and even with this disadvantage, very few could procure weft enough to keep themselves constantly employed. It was no uncommon thing for a weaver to walk three or four miles in a morning, and call on five or six spinners, before

he could collect weft to serve him for the remainder of the day; and when he wished to weave a piece in a shorter time than usual, a new ribband or gown was necessary to quicken the exertions of the spinner."

It was natural in this state of things, that attempts should be made to contrive some method of spinning more effective than that which had hitherto been in use; and, in fact, several ingenious individuals seem to have turned their attention to the subject. Long before this time, indeed, spinning by machinery had been thought of by more than one speculator. Mr. Wyatt, of Litchfield, is stated to have actually invented an apparatus for that purpose so early as the year 1733, and to have had factories built and filled with his machines, both at Birmingham and Northampton. These undertakings, however, not being successful, the machines were allowed to perish, and no model or description of them was preserved. There was also Mr. Laurence Earnshaw, of Mottram, in Cheshire, of whom "it is recorded that, in the year 1753, he invented a machine to spin and reel cotton at one operation, which he showed to his neighbors, and then destroyed it, through the generous apprehension that he might deprive the poor of bread,"—a mistake, but a benevolent one.

From the year 1767, it appears that Arkwright gave himself up completely to the subject of inventions for spinning cotton. In the following year, he began constructing his first machine at Preston, in the dwelling-house attached to the free grammar-school there. At this time, Arkwright's poverty was such, that being "a burgess of Preston," he could not appear to vote during a contested election till the party with whom he voted gave him a decent suit of clothes. Shortly after, apprehensive of meeting with hostility from one Hargrave, a carpenter at Blackburn, who had just invented the spinning-jenny,* Arkwright left Lancashire, and went to Nottingham. Here, after some disappointment of resources, he arranged with Messrs. Need and Jedediah Strutt, of Derby, the latter the ingenious improver and patentee of the stocking-frame;† and, with such aid, Arkwright resumed his experimental labors. He consulted Mr. Strutt upon the matter; and it is a remarkable fact, strongly corroborative of Arkwright's claim to be the original inventor, (which was subsequently disputed,) that although Mr. Strutt saw and acknowledged the great merit of the invention, he pointed out various deficiencies, which the inventor, from the want of me-

* The jenny gave the means of spinning twenty or thirty threads at once, with no more labor than had previously been required to spin a single thread.

† Mr. Strutt was the first individual who succeeded in adapting the stocking frame to the manufacture of ribbed stockings.

chanical skill, had been unable to supply. These defects were easily remedied by Mr. Strutt; and in the year 1769, Arkwright obtained his first patent for spinning with rollers, Messrs. Need and Strutt becoming his partners in the manufacturing concerns which it was proposed to carry on under it.

The improvement for which this patent was obtained, or the *spinning-frame,* spins a vast number of threads of any degree of fineness and hardness, leaving man merely to feed the machine with cotton, and to join the threads when they happen to break. The principle on which this machine is constructed, and its mode of operation, will be easily understood. It consists of two pairs of rollers turned by machinery. The lower roller of each pair is furrowed or fluted longitudinally, and the upper one is covered with leather, by which means the two have a sufficient hold upon the cotton passed between them. The cotton, when passed through the first pair of rollers, has the form of a thick but very soft cord, which is slightly pressed: but no sooner has the cotton carding, or *roving,* as it is technically called, begun to pass through the first pair of rollers, than it is received by the second pair, which are made to revolve with (as the case may be) twice, thrice, or ten times the velocity of the first pair, so that the cotton is necessarily drawn out twice, thrice, or ten times smaller than when delivered from the first rollers.

It is obvious that the principle of the spinning-frame is radically different from the previous methods of spinning, either by the common hand-wheel or distaff, or by the jenny, which is only a modification of the common wheel. Spinning by rollers was entirely an original idea, according to Arkwright, suggested to him by seeing a red-hot iron bar elongated by being made to pass between two rollers; and though there is no mechanical analogy between that operation and the process of spinning, it is not difficult to imagine that, by reflecting upon it, and placing the subject in different points of view, it might lead him to his invention.

The first mill erected for spinning cotton by this method was at Nottingham, and was worked by horse-power; but, in 1771, another mill was built at Cromford, in the parish of Wirksworth, in Derbyshire, to which motion was given by water; from this circumstance the machine was called the water-frame, and the thread received the name of water-twist.

Previous to this time, no establishment of a similar nature had existed, none, at least, to which the same system of management was applicable; and it strongly marks the judgment and mental powers of Arkwright, that although the details of manufacturing or commercial business were altogether new to him, he at once

introduced a system of arrangement into his works, which has since been universally adopted by others, and which, in all its main features, has remained unaltered to the present time.

Arkwright having made several additional improvements in the processes of carding, roving, and spinning, he next took out a fresh patent for the whole in the year 1775; and thus completed a series of machinery so various and complicated, yet so admirably combined and well adapted to produce the intended effect, in its most perfect form, as to excite the astonishment and admiration of every one capable of appreciating the ingenuity displayed and the difficulties overcome.

Arkwright did not, however, enjoy the rights of his ingenuity without opposition, alike from the manufacturers and the spinners and weavers. Repeated attacks were made by them on the factories built for Arkwright's machines; his patents were invaded by the manufacturers; while it became the fashion to depreciate his talents, and even to deny him altogether the merit of being an original inventor. Circumstantial accounts of this system of injustice towards Arkwright will be found in the History of the Cotton Manufacture. The details are too numerous for quotation here; but they will be readily found in the Encyclopædia Britannica, in which is this conclusion:—"We have access to know, that none of Mr. Arkwright's most intimate friends, and who were best acquainted with his character, ever had the slightest doubt with respect to the originality of his invention. Some of them, indeed, could speak to the circumstances from their own personal knowledge; and their testimony was uniform and consistent. Such also seems to be the opinion now generally entertained among the principal manufacturers of Manchester." In the Penny Cyclopædia it is remarked, that "if the evidence be fully weighed upon which it has been attempted to convict Arkwright of the serious charge, (of pirating other men's ideas,) we think it will be found to rest upon very slight grounds; while the proofs which he exhibited of possessing talents of the very highest order in the management of the vast concerns in which he was afterwards engaged, are unquestionable."

It was not until after the lapse of five years from their erection that by the works at Cromford any profit was realized; but from that time wealth flowed in abundantly to the proprietors. The establishments were greatly extended, several new ones were formed, and, in many cases, Arkwright took a share with other persons in the erection and working of cotton-mills. The tide to fortune had set in, and continued to flow, notwithstanding Arkwright's patent had been cancelled by law. "For several years,

the market prices of cotton twist were fixed by Arkwright, all other spinners conforming to his scale. The same quality of this article which now sells for 3*s.* per pound, sold in 1790 for ten times that price, and was as high as 1*l.* 18*s.* per pound; and although a great part of this difference is, no doubt, owing to a progressive economy attained in the processes of manufacture, it is not difficult to imagine that the larger price must have been exceedingly profitable to the spinner."

Meanwhile, Arkwright had almost built the town of Cromford in a deep valley on the south bank of the Derwent. The structures are chiefly of excellent gritstone procured in the neighborhood; and here Arkwright lived in patriarchal prosperity amidst the scenes of industry where he raised up his own fortune. The mills are to this day supplied from a never-failing spring of warm water, which also proves to be of great advantage to the canal in severe seasons, as it rarely freezes, in consequence of a portion of the water from this spring flowing into it. The mill engraved on the adjoining page is a spacious building near the upper end of the Dale: its operations have been elegantly described by Dr. Darwin, in his Botanic Garden,—" a work which discovers the art, hitherto unknown, of clothing in poetical language, and decorating with beautiful imagery, the unpoetical operations of mechanical processes, and the dry detail of manufactures:"—

" Where Derwent guides his dusky floods,
Through vaulted mountains, and a night of woods,
The nymph Gossypia treads the velvet sod,
And warms with rosy smiles the watery god;
His ponderous oars to slender spindles turns,
And pours o'er massy wheels his foaming urns;
With playful charms her hoary lover wins,
And wheels his trident, while the Monarch spins.
First, with nice eye emerging Naiads cull
From leathery pods the vegetable wool;
With wiry teeth revolving cards release
The tangled knots, and smooth the ravell'd fleece;
Next moves the iron hand with fingers fine,
Combs the wide card, and forms th' eternal line;
Slow with soft lips the whirling can acquires
The tender skeins, and wraps in rising spires;
With quicken'd pace successive rollers move,
And these retain, and those extend, the rove;
Then fly the spokes, the rapid axles glow;
While slowly circumvolves the lab'ring wheel below."

Nor was Cromford benefited only by the ingenuity of its founder in a commercial sense; for, having obtained the grant of a market for the town, he commenced building a chapel of freestone, which has since been completed by his son. He liberally contributed to educational and other charities. In 1786, he was appointed high

sheriff of Derbyshire, and, on the occasion of presenting an address of congratulation to the king on his escaping the attempt at assassination by Margaret Nicholson, Mr. Arkwright received the honor of knighthood. Though a man of great personal strength, during the whole of his active career he was laboring under a very severe asthma. Yet, to the latest period of his life, Sir Richard continued to give unremitted attention to business, and superintended the daily operations of his large establishments, adding from time to time such improvements to the machinery as were suggested by experience and observation. He sank, at length, under a complication of disorders, accelerated, if not produced, by his sedentary habits, and died in his house at Cromford, on August 3, 1792, in the sixtieth year of his age, leaving behind him a fortune estimated at little short of half a million.

The death of Sir Richard Arkwright was a sorrowful event to all classes of this district. His funeral was conducted with fitting splendor. Mr. Malcolm, the antiquarian, was entering Matlock from Chesterfield, at the time when the procession was passing to Matlock church, where the body was first interred; he says—"as the ground I was on was much higher than the Tor, or any of the hills at Matlock, I was at once surprised and delighted with the grand and awful scene that expanded below me; all the rich profusion of wild nature thrown together in an assemblage of objects the most sublime. To heighten the view, the Tor, and rocks near it, were covered with crowds of people. . . . . The road was nearly impassable, from the crowds of people who had assembled to witness the procession. The ceremony was conducted with much pomp, and, as nearly as I can remember, was thus: a coach and four with the clergy; another with the pall-bearers; the hearse, covered with escutcheons, and surrounded by mutes, followed; then the horse of the deceased, led by a servant; the relations, and about fifteen or twenty carriages, closed the procession, which was nearly half a mile in length. The evening was gloomy, and the solemn stillness that reigned was only interrupted by the rumbling of the carriages, and the gentle murmurs of the river; and, as they passed, the echo of the Tor gently returned the sound. The scene was so rich and uncommon that I continued to gaze till a turn in the road closed the whole. How greatly would the effect have been heightened by a choir chanting a *dirge!*"

The body was subsequently removed to Cromford chapel, wherein is the family vault of the Arkwrights, with a beautiful monument by Chantrey.

The character of Sir Richard Arkwright is one upon which we could linger with untiring interest; so fine a specimen was he of

genius, industry, and perseverance: he was, indeed, one of the honorables of the land. In the Encyclopædia Britannica, it is truly remarked: "No man ever better deserved his good fortune, or has a stronger claim on the respect and gratitude of posterity. His inventions have opened a new and boundless field of employment; and while they have conferred infinitely more real benefit on his native country than she could have derived from the absolute dominion of Mexico and Peru, they have been *universally* productive of wealth and enjoyments."

The most marked traits of Arkwright were his wonderful ardor, energy, and perseverance. He commonly labored in his multifarious concerns from five o'clock in the morning till nine at night; and that, too, when considerably more than fifty years of age. Feeling that his defects of education placed him under great difficulty and inconvenience in conducting his correspondence, and in the general management of his business, he encroached upon his sleep, in order to gain an hour each day to learn English grammar, and another hour to improve his writing and orthography. He was impatient of whatever interfered with his favorite pursuits; and the fact is too strikingly characteristic not to be mentioned, that he separated from his wife not many years after their marriage, because she, convinced that he would *starve* his family by *scheming* when he should be *shaving*, broke some of his experimental models of machinery. He was a severe economist of time; and, that he might not waste a moment, generally travelled with four horses at full speed. His concerns in Derbyshire, Lancashire, and Scotland were so extensive and numerous, as to show at once his astonishing power of transacting business. Indeed, his schemes were vast and daring, as his talents were great and his industry indefatigable.

Thus it was from a poor barber he raised himself to what he eventually became—not merely to rank and great affluence, but to be the founder of a new branch of national industry, destined, in a wonderfully short space of time, to assume the very first place among the manufactures of his country. So great has been its increase, that it has been calculated that, while the number of persons in his native country, previous to his inventions, who were employed in the cotton manufacture, did not probably amount to thirty thousand, the number now engaged in its different departments can hardly be less than a million. Yet, in some branches of the business, it has been stated, the spinning in particular, such is the economy of labor introduced by the use of machinery, that one man and four children will spin as much yarn as was spun by six hundred women and girls, seventy years ago!

M. GUINAND

About eighty years have elapsed, since this interesting man was employed in assisting his father, as a joiner, in a remote village among the mountains of Neufchatel, in Switzerland. His parent must have been in very indifferent circumstances, as his son was thus engaged when only ten years of age. His early education was much neglected; indeed, he never acquired more than an imperfect knowledge of the first rudiments of learning, always reading with difficulty, and writing very imperfectly. He must, even at this early period, have been a lad of considerable talent, and of a disposition that urged him to the exertion requisite for raising his condition in society. We find him, when between thirteen and fourteen years old, having quitted the employment of a joiner for that of a cabinetmaker, chiefly engaged in making cases for clocks.

At this period he became acquainted with a buckle maker, who lived in the neighborhood, and of whom he learned the art of casting, and working in various metals, which enabled him about the age of twenty, after once witnessing the process, to attempt the construction of a watch case; having succeeded, he adopted the occupation of a watch-case maker, which was then very lucrative.

Having constructed clock cases for M. Jaquet Droz, the well known constructor of several automaton figures, which fifty years ago made the tour of Europe, he had an opportunity of seeing, at the house of that celebrated mechanist, a very fine English reflecting telescope, which appeared to him extremely curious and interesting. These instruments were very rare at that time in Switzerland, especially among the mountains. M. Guinand was then in his twentieth or twenty-third year, and it cannot be doubted that this circumstance, in itself unimportant, first turned his mind towards that subject, to which, encouraged by success, he afterwards more particularly devoted himself.

Be that as it may, having expressed a wish to be allowed to take to pieces this telescope, that he might examine it in detail, M. Jaquet Droz, who had noticed his dexterity, kindly gave him permission, and with equal good-nature relieved him from his apprehension of being unable to put it together again, by taking that task upon himself, if it should prove too difficult for him. Thus encouraged, he took the instrument to pieces, accurately measured the curves of the reflectors and glasses, and afterwards readily

put it together; then availing himself of the few notions of metallurgy which he had acquired from his friend the buckle maker, as well as the experience he had acquired in casting ornaments for clock cases, he attempted the construction of a similar telescope, and the experiment succeeded so well, that on a comparative trial of his own instrument with that which had been its model in presence of a great number of persons, it was impossible to determine which of them the preference was due.

M. Jaquet Droz, surprised at his success, asked our young friend what treatise on optics he had followed as his guide, and was astonished when he informed him that he was unacquainted with any. He then placed one in his hands; and it was not until this period that M. Guinand studied, or rather deciphered the principles of that science.

About the same time occurred another fortunate circumstance, in itself as trivial as the former. Having been always weak sighted, he found, when he began to make watch cases, that the spectacles which had hitherto answered his purpose, were no longer of service, and being directed to a person whose glasses were said to have given great satisfaction, he obtained a pair, which really suited him no better than the others, but by looking on while they were making, he learned the art of forming and polishing the lenses. He, therefore, undertook to make spectacles, not only for himself, but for various other persons, who pronounced them excellent. This new acquirement he found very useful in his favorite pursuit; and he amused himself in manufacturing great numbers of telescopes of an inferior quality, for which he made the tubes himself, generally of pasteboard. He also studied the small number of works he was able to procure, which treated on subjects connected with optics.

Meanwhile the ingenious and important discovery of achromatic glasses was beginning to spread; and having reached that country, it could not fail of being very interesting to M. Guinand, who listened with avidity to all he heard on this subject. M. Jaquet Droz, having procured one of these new glasses, permitted M. Guinand, as in the instance of the reflecting telescope, to take it to pieces, and to separate the lenses. It will be readily conceived that the purpose of the latter was to attempt the construction of a similar instrument, but in this he was impeded by the difficulty of procuring glasses of different refractive power. It was not until some years after, that an acquaintance of his, M. Recordon, having proceeded to England, where he obtained a patent for his self-winding watches, which were then in great request, brought him from that country some flint glass; and though the specimen

was much striated, he found means to manufacture from it some tolerably good achromatic glasses.

Having obtained supplies of this material on various occasions, and having seen other glasses besides those of M. Jaquet Droz, he easily ascertained that flint glass which is not extremely defective, is rarely to be met with. Thus convinced of the impossibility of procuring it of that quality which he ardently wished to obtain for the construction of his telescopes, and having by his various labors become sufficiently skilled in the art of fusion, he melted in his blast furnace the fragments of this flint glass; no satisfactory result was obtained, but he discovered from some particles of lead which reappeared during the process, that this metal was a constituent in the composition of flint glass. At the time of his first experiment he had attained his thirty fifth or sixth year. The ardent desire to obtain some of this glass then induced him to collect from the different works he was able to procure, such notions of chemistry as might be useful to him in his attempts at vitrification; and during six or seven years he employed a part of his evenings in different experiments, melting at each time in his blast furnace three or four pounds of glass; he took care, in every experiment, to note down the substance and proportions of his combinations, the time of their fusion, and as nearly as possible the degree of heat to which he had subjected them; then, by an attentive examination of the results of his experiments, he endeavored to discover the causes which had rendered his products defective, in order that he might remedy them in a subsequent trial. While occupied in these researches he derived a strong incentive to perseverance, from the prizes which he understood to have been offered for this desideratum by different academies, and especially by the Royal Society of London, a copy of whose proposals was procured for him. At a later period he also learned in a more positive manner, from statements given in a work which fell into his hands, of the almost total impossibility which existed of procuring flint glass exempt from striæ; all this impressed him with the importance of the discovery at which he was aiming, and stimulated him in the pursuit. These experiments, however, were made, as he observed, on too small a scale, and proved fruitless.

At the age of forty and upwards, having relinquished the trade of watch-case maker for that of maker of bells for repeaters, at that time very lucrative, (since he could make as many as twenty-four in a day, for which he was paid five francs each,) he resolved to prosecute his experiments on a more extended scale. Having purchased a retired place on the banks of the Doubs, near the Brenets, where the establishment is at present situated, he constructed

with his own hands a furnace capable of melting at one time two hundred weight of glass, and settled there with his family on a very economical plan, in order to dedicate all his earnings and leisure to new and expensive experiments; yet he was compelled to employ an interval between each one of his experiments in earning at his regular employment sufficient means for subsistence, and for providing the apparatus and materials needful for renewing them.

In this pursuit he was still exposed to numerous accidents and difficulties, which would have deterred most persons from continuing the research. His furnace, which he had constructed with his own hands, out of such materials as he could procure, and which was capable of melting at once two hundred pounds of glass, proved defective. He was then obliged to procure materials for the purpose from abroad, and having once more completed its erection, and consumed much fuel in heating it, had the mortification to find that it still required alteration. Then his crucibles, which he was equally obliged to form with materials ill-qualified for the object, cracked during the process, and the contents were lost among the ashes. All this time the pursuit had laid hold so completely of his mind, that he was deprived of his natural rest while considering upon the causes of his various failures, and endeavoring to reason out the means for their prevention.

Having at length succeeded in obtaining a block of glass weighing about two hundred pounds, and having sawn it into two vertical sections, he polished one of the faces, in order, as far as possible, to examine the circumstances produced by the fusion.

To account for the numerous and various defects exhibited by this specimen, Guinand formed a theory which he made the groundwork of his future operations. A more intimate knowledge of these defects, and a conviction thus attained of the great difficulties opposed to their removal, instead of damping his ardor in the pursuit, served to infuse new energy into his mind. Nor was he mistaken in his estimate of the obstacles to be surmounted; "so that," as he himself declared, "the sacrifices and exertions which he had previously made, were trifling when compared with those which he afterwards underwent for the purpose of removing these various defects, and of rendering his glass homogeneous."

The steps through which he pursued this arduous undertaking, and the methods by which its success was accomplished, it is not possible to detail. All that is publicly known upon the subject is, that he succeeded in discovering a mode of proceeding which gave the almost certainty of producing in the fusion of a pot containing from two to four hundred pounds of glass, one half at least of its substance entirely of the same nature, and therefore fitted for the

construction of perfect optical instruments. With this result, satisfactory as it would have been to most men, Guinand expressed himself by no means contented, and continued his researches, without, however, ever arriving much nearer to perfection in the art. He was now enabled to make use of, for discs, glass perfectly homogeneous, with a diameter of twelve inches: a great achievement, when compared with what had been at any time accomplished by others.

A year or two before his death, he tried an experiment on a larger scale than any he had previously attempted. After much trouble and exertion, he succeeded in obtaining a disc of eighteen inches in diameter, of perfectly homogeneous glass. The disc had been put into the oven for the last time, to be gradually cooled: and the operation being now considered as completed, his friends and neighbors were admitted, and partook of some refreshment; while offering their congratulations on his unprecedented success after so long a seclusion, the fire by some accident or neglect caught the roof of the building. On this alarming occasion all present exerted themselves, and after some trouble the flames were extinguished; but not before some water had found its way into the oven and destroyed its precious contents. The discouragement caused by this misfortune, and some other circumstances, ever after prevented him from any experiment on a similar scale.

For some time after he had thus far succeeded in his object, he was accustomed to divide his blocks of glass by that which appeared to be the only fitting method, sawing them into sections perpendicular to their axis, polishing their sections, and then selecting such parts as were adapted to his purpose, returning the remaining portion to the crucible for farther operations. By this means he had frequently the mortification of perceiving, that the glass was divided so as to present a less extended surface of the perfect material, than the state of the block would, if previously known, have rendered possible; and he was frequently able to procure discs of only small diameter, when, could he have been fully aware of the particular circumstances of the glass throughout its substance, he might, by cutting in another direction, have obtained a more satisfactory result.

This disadvantage was remedied in a way apparently as untoward as it was singular and unexpected. While his men were carrying one day a block of glass on a handbarrow to a water sawmill, which he had constructed at the fall of the river Doubs, a short distance from his dwelling, the mass accidentally slipped, and rolling to the bottom of a rocky declivity, was broken into several pieces. Endeavoring to make the best of this seeming misfortune

such fragments of glass were selected for operation as appeared to be fitted by their homogeniety for the purpose; and these were softened in circular moulds, in such a manner that they furnished discs of a very satisfactory quality. Further examination enabled him to perceive that the fracture had in a great measure followed the variations of density in the glass; and, pursuing the idea thus obtained, the artist thenceforth adhered to a method so singularly in the first instance forced upon him.

After this, he contrived a mode of cleaving the glass while cooling, so that the fracture accompanied the direction of the more faulty parts; by which course he frequently obtained masses of glass which were absolutely homogeneous, weighing from forty to fifty pounds. These masses, cleft again by means of wedges into pieces of convenient shape, were remelted into moulds which gave them the form of discs; an operation which differs essentially from that used by other glass makers.

Several years of his life were thus employed in making bells for repeating watches and constructing achromatic telescopes with glass of his own preparing. The retired spot wherein he resided, offered only very limited opportunities for acquiring a reputation in the world; yet, by degrees, the superior value of his labors became appreciated, and he was visited by such men of science as travelled in the neighborhood of his dwelling. By one of these a knowledge of his merits was conveyed to M. Frauenhofer, the chief of a celebrated manufactory for optical instruments, established at Benedictbeurn, in Bavaria. This gentleman having, in consequence, obtained some discs of glass made by Guinand, found their quality so satisfactory, that he repaired in person to Brenets, where Guinand resided, and engaged him to settle in Bavaria. This was in 1805, when Guinand was upwards of sixty years of age. He continued at this place during nine years, occupied solely in the manufacture of glass, to the great increase of his employer's reputation.

Being desirous, at the end of this time, to return to his native land, a pension was granted to him by the establishment, on condition that he should no longer employ himself in making glass, nor disclose his process to any person whatever; a condition which did not long agree with the still active energies of his mind. Believing, by new experiments, he could raise his discovery to a yet higher degree of improvement, he obtained the consent of Frauenhofer, to cancel their subsisting agreement; and, relinquishing his pension, once again devoted himself with ardor to his favorite pursuit.

He lived seven years after this time, and produced several

telescopes of great magnitude, and remarkable for their excellence; it being perhaps not the least extraordinary among the circumstances attending them, that, to use the words of the memoir from whence the foregoing account is drawn, "they have been constructed by an old man upwards of seventy, who himself manufactures the flint and crown glass which he uses in their construction, after having made, with his own hands, the vitrifying furnace and his crucibles; who, without any mathematical knowledge, devises a graphic method of ascertaining the proportions of the curves that must be given to the lenses, afterwards works and polishes them by means peculiar himself, and lastly, constructs all the parts of the different mountings either with joints or with stands, melts and turns the plates, solders the tube, prepares the wood, and compounds the varnish."

M. Guinand died in 1823, in his eightieth year. The preceding pages show how greatly his loss is to be deplored. After half a century of research, he was the only man in Europe who had succeeded in obtaining large specimens of that *flint glass* which is so indispensable for the construction of achromatic lenses, and at the same time so difficult to obtain free from striæ in any considerable magnitude. Arrangements had been made by the French government for purchasing his secret at the time of his death. In the latter part of his life he was assailed by infirmities incident to his multifarious labors and advanced age. It is to be lamented, that after sacrificing so much to his art, so much more than could have been expected from a man in his circumstances, he should derive from them so little advantage; and lastly, it is painful to think that this man, in attaching so little importance to the honor of his discovery, should not have made it more extensively known, and connected it more closely with his name; since it is a discovery which, by the perfection it imparts to telescopes, opens the way to very important acquisitions in the vast field which the heavens still offer to optical instruments in a state of perfection The secret, however, did not die with him, but is possessed by his son, who continues to labor in the employment so singularly commenced, and so energetically and successfully followed by the father.

JAMES WATT.

"Nature, in her productions slow, aspires
By just degrees to reach perfection's height
So mimic art works leisurely, till time
Improve the price, or wise experience give
The proper finishing."

ALL the inventions and improvements of recent times, if measured by their effects upon the condition of society, sink into insignificance, when compared with the extraordinary results which have followed the employment of steam as a mechanical agent. To one individual, the illustrious JAMES WATT, the merit and honor of having first rendered it extensively available for that purpose are pre-eminently due. The force of steam, now so important an agent in mechanics, was nearly altogether overlooked until within the two last centuries. The only application of it which appears to have been made by the ancients, was in the construction of the instrument which they called the Æolipile, that is, the Ball of Æolus. The Æolipile consisted of a hollow globe of metal, with a long neck, terminating in a very small orifice, which, being filled with water and placed on a fire, exhibited the steam, as it was generated by the heat, rushing with apparently great force through the narrow opening. A common teakettle, in fact, is a sort of Æolipile. The only use which the ancients proposed to make of this contrivance was, to apply the current of steam, as it issued from the spout, by way of a moving force—to propel, for instance, the vans of a mill, or, by acting immediately upon the air, to generate a movement opposite to its own direction. But it was impossible that they should have effected any useful purpose by such methods of employing steam. Steam depends so entirely for its existence in the state of vapor upon the presence of a large quantity of heat, that it is reduced to a mist or a fluid almost immediately on coming into contact either with the atmosphere, or any thing else which is colder than itself; and in this condition its expansive force is gone. The only way of employing steam with much effect, therefore, is to make it act in a close vessel. The first known writer who alludes to the prodigious energy which it exerts when thus confined, is the French engineer Solomon de Caus, who flourished in the beginning of the seventeenth century. This ingenious person, who came to England in 1612, in the train of the Elector Palatine, afterwards the son-in-law of James I., where he resided for some years, published a folio volume at Paris,

in 1623, on moving forces; in which he states, that if water be sufficiently heated in a close ball of copper, the air or steam arising from it will at last burst the ball, with a noise like the going off of a petard. In another place, he actually describes a method of raising water, as he expresses it, by the aid of fire, which consists in the insertion, in the containing vessel, of a perpendicular tube, reaching nearly to its bottom, through which, he says, all the water will rise, when sufficiently heated. The agent here is the steam produced from part of the water by the heat, which, acting by its expansive force upon the rest of the water, forces it to make its escape in a jet through the tube. The supply of the water is kept up through a cock in the side of the vessel. Forty years after the publication of the work of De Caus appeared the Marquis of Worcester's famous "Century of Inventions." Of the hundred new discoveries here enumerated, the sixty-eighth is entitled "An admirable and most forcible way to drive up water by fire." As far as may be judged from the vague description which the marquis gives us of his apparatus, it appears to have been constructed upon the same principle with that formerly proposed by De Caus; but his account of the effect produced is considerably more precise than what we find in the work of his predecessor. "I have seen the water run," says he, "like a constant fountain-stream forty feet high; one vessel of water rarified by fire, driveth up forty of cold water." This language would imply that the marquis had actually reduced his idea to practice; and if, as he seems to intimate, he made use of a cannon for his boiler, the experiment was probably upon a considerable scale. It is with some justice, therefore, that notwithstanding the earlier announcements in the work of the French engineer, he is generally regarded as the first person who really constructed a steam engine.

About twenty years after this, namely, in the year 1683, Sir Samuel Morland appears to have presented a work to the French king, containing, among other projects, a method of employing steam as a mechanic power, which he expressly says he had himself invented the preceding year. The manuscript of this work is now in the British Museum; but it is remarkable that when the work, which is in French, was afterwards published by its author at Paris, in 1685, the passage about the steam engine was omitted. Sir Samuel Morland's invention, as we find it described in his manuscript treatise, appears to have been merely a repetition of those of his predecessors, De Caus and the Marquis of Worcester; but his statement is curious as being the first in which the immense difference between the space occupied by water in its natural state and that which it occupies in the state of steam is numerically de-

signated. The latter, he says, is about two thousand times as great as the former; which is not far from a correct account of the expansive force that steam exerts under the ordinary pressure of the atmosphere. One measure of water, it is found in such circumstances, will produce about seventeen hundred measures of steam.

The next person whose name occurs in the history of the steam engine, is Denis Papin, a native of France, but who spent the part of his life during which he made his principal pneumatic experiments in England. Up to this time, the reader will observe, the steam had been applied directly to the surface of the water, to raise which, in the form of a jet, by such pressure, appears to have been almost the only object contemplated by the employment of the newly discovered power. It was Papin who first introduced a piston into the tube or cylinder which rose from the boiler. This contrivance, which forms an essential part of the common sucking-pump, is merely, as the reader probably knows, a block fitted to any tube or longitudinal cavity, so as to move freely up and down in it, yet without permitting the passage of any other substance between itself and the sides of the tube. To this block a rod is generally fixed; and it may also have a hole driven through it, to be guarded by a valve, opening upwards or downwards, according to the object in view. Long before the time of Papin it had been proposed to raise weights, or heavy bodies of any kind, by suspending them to one extremity of a handle or cross-beam attached at its other end to the rod of a piston moving in this manner in a hollow cylinder, and the descent of which, in order to produce the elevation of the weights, was to be effected by the pressure of the superincumbent atmosphere after the counterbalancing air had been by some means or other withdrawn from below it. Otto Guericke used to exhaust the lower part of the cylinder, in such an apparatus, by means of an air-pump. It appeared to Papin that some other method might be found of effecting this end more expeditiously and with less labor. First he tried to produce the requisite vacuum by the explosion of a small quantity of gunpowder in the bottom of the cylinder, the momentary flame occasioned by which he thought would expel the air through a valve opening upwards in the piston, while the immediate fall of the valve, on the action of the flame being spent, would prevent its re-intrusion. But he never was able to effect a very complete vacuum by this method. He then, about the year 1690, bethought him of making use of steam for that purpose. This vapour, De Caus had long ago remarked, was recondensed and restored to the state of water by cold; but up to this time the attention of no person seems to have

been awakened to the important advantage that might be taken of this one of its properties. Papin for the first time availed himself of it in his lifting machine, to produce the vacuum he wanted. Introducing a small quantity of water into the bottom of his cylinder, he heated it by a fire underneath, till it boiled and gave forth steam, which, by its powerful expansion, raised the piston from its original position in contact with the water, to a considerable height above it, even in opposition to the pressure of the atmosphere on its other side. This done, he then removed the fire, on which the steam again became condensed into water, and, occupying now about the seventeen hundredth part of its former dimensions, left a vacant space through which the piston was carried down by its own gravitation and the pressure of the atmosphere.

The machine thus proposed by Papin was abundantly defective in the subordinate parts of its mechanism, and, unimproved, could not have operated with much effect. But, imperfect as it was, it exemplified two new principles of the highest importance, neither of which appears to have been thought of, in the application of the power of steam, before his time. The first is the communication of the moving force of that agent to bodies upon which it cannot conveniently act directly, by means of the piston and its rod. The second is the deriving of the moving force desired, not from the expansion of steam, but from its other equally valuable property of condensibility by mere exposure to cold. Papin, however, it is curious enough, afterwards abandoned his piston and method of condensation, and reverted to the old plan of making the steam act directly by its expansive force upon the water to be raised. It is doubtful, however, whether he ever actually erected any working engine upon either of these constructions. Indeed, the improvement of the steam engine could scarcely be said to have been the principal object of those experiments of his which, nevertheless, contributed so greatly to that result. It was, in fact, as we have seen, with the view of perfecting a machine contrived originally without any reference to the application of steam, that he was first induced to have recourse to the powers of that agent. The moving force with which he set out was the pressure of the atmosphere; and he employed steam merely as a means of enabling that other power to act. Even by such a seemingly subordinate application, however, of the new element, he happily discovered and bequeathed to his successors the secret of some of its most valuable capabilities.

We may here conveniently notice another ingenious contrivance, of essential service in the steam engine, for which we are also indebted to Papin—we mean the safety-valve. This is merely a lid

or stopper, closing an aperture in the boiler, and so loaded as to resist the expansive force of the steam up to a certain point, while, at the same time, it must give way and allow free vent to the pent-up element, long before it can have acquired sufficient strength to burst the boiler. The safety-valve, however, was not introduced into the steam engine either by Papin, or for some years after his time. It was employed by him only in the apparatus still known by the name of his *digester*, a contrivance for producing a very powerful heat in cookery and chemical preparations, by means of highly concentrated steam.

We now come to the engine invented by Captain Savery in 1698. This gentleman, we are told, having one day drank a flask of Florence wine at a tavern, afterwards threw the empty flask upon the fire, when he was struck by perceiving that the small quantity of liquid still left in it very soon filled it with steam, under the influence of the heat. Taking it up again while thus full of vapor, he now plunged it, with the mouth downwards, into a basin of cold water which happened to be on the table; by which means the steam being instantly concentrated, a vacuum was produced within the flask, into which the water immediately rushed up from the basin. According to another version of the story, it was the accidental circumstance of his immersing a heated tobacco-pipe into water, and perceiving the water immediately rush up through the tube, on the concentration by the cold of the warm and thin air, that first suggested to Savery the important use that might be made of steam, or any other gas expanded by heat, as a means of creating a vacuum. He did not, however, employ steam for this purpose in the same manner that Papin had done. Instead of a piston moving under the pressure of the atmosphere through the vacuum produced by the concentration of the steam, he availed himself of such a vacuum merely to permit the rise of the water into it from the well or mine below, exactly as in the common sucking-pump. Having thus raised the water to the level of the boiler, he afterwards allowed it to flow into another vessel, from whence he sent it to a greater height by the same method which had been many years before employed by the Marquis of Worcester,—namely, by making the expansive force of the steam act upon it directly, and so force it up in opposition to its own gravity and the resistance of the atmosphere.

Savery showed much ingenuity and practical skill in contriving means of facilitating and improving the working of the apparatus which he had devised upon these principles; and many of his engines were erected for supplying gentlemen's houses with water and other purposes, in different parts of the country. The ma-

chine also received many improvements after the death of the original inventor. It was considerably simplified, in particular, by Dr. Desaguliers, about the year 1718; and this gentleman also contrived a method of concentrating the steam by the injection of a small current of cold water into the receiver, instead of the old method employed by Savery, of dashing the water over the outside of the vessel, which cooled it to an unnecessary degree, and occasioned, therefore, a wasteful expenditure of fuel. It was Desaguliers who first introduced the safety-valve into the steam engine, although Papin had previously suggested such an application of the contrivance. Engines upon Savery's principle have continued to be constructed, down to our own times; and as they can be made at a comparatively small expense, they are found to answer very well in situations where water has to be raised only a short way. This engine is, in fact, merely a combination of the common sucking-pump, (except that the requisite vacuum is produced by the condensation of steam and without the aid of a piston,) with the contrivance proposed by De Caus and the Marquis of Worcester for the application of the expansive force of steam; and, wherever the machine can be economically employed, the former part of it is that which operates with by far the most effect.

Not long after Savery had invented his engine, Thomas Newcomen, an ironmonger, and John Calley, a glazier, both of Dartmouth, in Devonshire, began also to direct their attention to the employment of steam as a mechanic power. Their first engine was constructed about the year 1711. This contrivance, which is commonly known by the name of Newcomen's engine, proceeded mainly upon the principle formerly adopted by Papin, but subsequently abandoned both by him and those who immediately followed him in the cultivation of this department of mechanics, of making the moving power of the machinery the weight of the atmosphere acting upon a piston, so as to carry it down through a vacuum created by the condensation of the steam. Newcomen's apparatus is, on this account, often distinguished by the name of the Atmospheric engine. Its inventors, however, instead of adopting Papin's clumsy method of cooling his steam by the removal of the fire, employed, in the first instance, the expedient of pouring cold water on the containing vessel, as Savery had done before them, though without being aware, it is said, of his prior claim to the improvement. They afterwards exchanged this for the still better method, already described as introduced by Desaguliers into Savery's engine, of injecting a stream of water into the cylinder, which is said to have been suggested to them by the accident of some water having found admission to the steam through a hole

which happened to have worn itself in the piston. This engine of Newcomen, which, in the course of a very few years after its invention, was brought to as high a state of perfection as the principle seems to admit of, afforded the first important exemplification of the value of steam in mechanics. Savery's, the only other practical contrivance which had been proposed, had been found quite inadequate to the raising of water from any considerable depth, its principal power, as we have already remarked, lying, in fact, in the part of it which acted as a sucking-pump, and by which, as such, water could only be raised till its column was of equal weight with a column of the atmosphere of the same base. It was nearly useless, therefore, as an apparatus for pumping up water from mines; the grand object for which a moving force of extraordinary power was at this time in demand. But here Newcomen's engine proved of essential service. Many mines that had long remained unwrought, were, immediately after its invention, again rendered accessible, and gradually excavated to great depths; while others were opened, and their treasures sought after with equal success, which but for its assistance could never have been attempted. It was applied also to various other important purposes.

Newcomen's engine, however, notwithstanding its usefulness, especially in cases where no other known power could be applied, was still in some respects a very defective contrivance, and by no means adapted to secure the complete command of the energies of steam. The great waste of fuel, in particular, which was still occasioned by the degree to which the cylinder was cooled after every stroke of the piston, from the cold water injected into it, rendered it scarcely any saving of expense to employ this engine in circumstances where animal power was available. Its whole force too, the reader will observe, as a moving power, was limited to what could be obtained by atmospheric pressure alone, which, even could the vacuum under the piston have been rendered quite perfect, and all obstructions from friction annihilated, could only have amounted to about fifteen pounds for every square-inch of the surface of the piston. The expansive force of steam was not, in fact, at all employed in this contrivance as a moving power; could the vacuum necessary to permit the descent of the piston have been as expeditiously and conveniently produced by any other agency, that of steam might have been dispensed with altogether. An air-pump, for instance, attached to the lower part of the cylinder, as originally proposed by Otto Guericke, might have rendered all the service which steam was here called upon to perform; and in that case, this element, with the fuel by which

it was generated, might have been dispensed with, and the machine would not have been a steam engine at all. This view of the matter may, in some degree, account for the complete neglect of steam as a moving power which so long prevailed after Newcomen's engine was brought into use, notwithstanding the proofs of its capabilities in that character which had been afforded by the attempts of the earlier speculators. It was now regarded simply as affording the easiest means of obtaining a ready vacuum, in consequence of its property of rapid condensation on the application of cold: its other property of extraordinary expansion, which had first attracted to it the attention of mechanicians, and presented in reality a much more obvious application of it as a mechanical agent, had been entirely neglected. The only improvements of the engine which were attempted or thought of were such as referred to what may be called its subordinate mechanism, that is to say, the contrivances for facilitating the alternate supplies of the steam and the water on which its action depended; and after Mr. Beighton had, about the year 1718, made the machine itself shut and open the cocks by which these supplies were regulated, instead of having that service performed as at first by an attendant, there remained little more to be done even in this department. The steam might be applied with more ease and readiness, but not with any augmentation of effect; the power of the engine could be increased only by a more plentiful application of atmospheric pressure. It was with propriety, therefore, that Newcomen's invention was called, not a steam, but an atmospheric, engine.

For half a century, accordingly, after the improvements introduced by Beighton, who may be considered as the perfecter of this engine, no farther progress worth mentioning was made in the application of steam as an agent in mechanics. The engine itself was more and more extensively employed, notwithstanding its defects; but no better method was proposed of calling into exercise the stupendous powers of the element, which, by means of only one of its remarkable properties, was here shown to be capable of rendering such valuable service. Our knowledge of what might be done by steam was in this state when the subject at last happily attracted the attention of Mr. Watt.

James Watt was born at Greenock, on the 19th of January, 1736. His father was a merchant, and also one of the magistrates of that town. He received the rudiments of his education in his native place; but his health being even then extremely delicate, as it continued to be to the end of his life, his attendance at school was not always very regular. He amply made up,

however, for what he lost in this way by the diligence with which he pursued his studies at home, where without any assistance he succeeded at a very early age in making considerable proficiency in various branches of knowledge. Even at this time his favorite study is said to have been mechanical science, to a love of which he was probably in some degree led by the example of his grandfather and his uncle, both of whom had been teachers of the mathematics, and had left a considerable reputation for learning and ability in that department. Young Watt, however, was not indebted to any instructions of theirs for his own acquirements in science, the former having died two years before, and the latter the year after, he was born. At the age of eighteen he was sent to London to be apprenticed to a maker of mathematical instruments; but in little more than a year the state of his health forced him to return to Scotland; and he never received any farther instruction in his profession. A year or two after this, however, a visit which he paid to some relations in Glasgow suggested to him the plan of attempting to establish himself in that city in the line for which he had been educated. In 1757, accordingly, he removed thither, and was immediately appointed mathematical instrument maker to the College. In this situation he remained for some years, during which, notwithstanding almost constant ill-health, he continued both to prosecute his profession, and to labor in the general cultivation of his mind, with extraordinary ardor and perseverance. Here also he enjoyed the friendship and intimacy of several distinguished persons who were then members of the University, especially of the celebrated Dr. Black, the discoverer of the principle of latent heat, and Mr. (afterwards Dr.) John Robison, so well known by his treatises on mechanical science, who was then a student and about the same age with himself. Honorable, however, as his present appointment was, and important as were many of the advantages to which it introduced him, he probably did not find it a very lucrative one; and therefore, in 1763, when about to marry, he removed from his apartments in the University to a house in the city, and entered upon the profession of a general engineer.

For this his genius and scientific attainments admirably qualified him. Accordingly, he soon acquired a high reputation, and was extensively employed in making surveys and estimates for canals, harbors, bridges, and other public works. His advice and assistance indeed were sought for in almost all the important improvements of this description which were now undertaken or proposed in his native country. But another pursuit, in which he had been for some time privately engaged, was destined ere long to with-

draw him from this line of exertion, and to occupy his whole mind with an object still more worthy of its extraordinary powers.

While yet residing in the College his attention had been directed to the employment of steam as a mechanical agent by some speculations of his friend Mr. Robison, with regard to the practicability of applying it to the movement of wheel-carriages ; and he had also himself made some experiments with Papin's digester, with the view of ascertaining its expansive force. He had not prosecuted the inquiry, however, so far as to have arrived at any determinate result, when, in the winter of 1763–4, a small model of Newcomen's engine was sent to him by the Professor of Natural Philosophy to be repaired, and fitted for exhibition in the class. The examination of this model set Watt upon thinking anew, and with more interest than ever, on the powers of steam.

The first thing that attracted his attention about the machine before him, the cylinder of which was only of two inches diameter, while the piston descended through six inches, was the insufficiency of the boiler, although proportionably a good deal larger than in the working engines, to supply the requisite quantity of steam for the creation of the vacuum. In order to remedy this defect he was obliged, in repairing the model, to diminish the column of water to be raised ; in other words, to give the piston less to do, in compensation for its having to descend, not through a perfect vacuum, but in opposition to a considerable residue of undisplaced air. He also soon discovered the reason why in this instance the steam sent up from the boiler was not sufficient to fill the cylinder. In the first place, this containing vessel, being made, not of cast-iron, as in the larger engines, but of brass, abstracted more of the heat from the steam, and so weakened its expansion ; and secondly, it exposed a much larger surface to the steam, in proportion to its capacity, than the cylinders of the larger engines did, and this operated still more strongly to produce the same effect. Led by the former of these considerations, he made some experiments in the first instance with the view of discovering some other material whereof to form the cylinder of the engine which should be less objectionable than either brass or cast-iron ; and he proposed to substitute wood, soaked in oil, and baked dry. But his speculations soon took a much wider scope ; and, struck with the radical imperfections of the atmospheric engine, he began to turn in his mind the possibility of employing steam in mechanics, in some new manner which should enable it to operate with much more powerful effect. This idea having got possession of him, he engaged in an extensive course of experiments, for the purpose of ascertaining as many facts as possible

with regard to the properties of steam; and the pains he took in this investigation were rewarded with several valuable discoveries. The rapidity with which water evaporates, he found, for instance, depended simply upon the quantity of heat which was made to enter it; and this again on the extent of the surface exposed to the fire. He also ascertained the quantity of coals necessary for the evaporation of any given quantity of water, the heat at which water boils under various pressures, and many other particulars of a similar kind which had never before been accurately determined.

Thus prepared by a complete knowledge of the properties of the agent with which he had to work, he next proceeded to take into consideration, with a view to their amendment, what he deemed the two grand defects of Newcomen's engine. The first of these was the necessity arising from the method employed to concentrate the steam, of cooling the cylinder, before every stroke of the piston, by the water injected into it. On this account, a much more powerful application of heat than would otherwise have been requisite was demanded for the purpose of again heating that vessel when it was to be refilled with steam. In fact, Watt ascertained that there was thus occasioned, in the feeding of the machine, a waste of not less than three fourths of the whole fuel employed. If the cylinder, instead of being thus cooled for every stroke of the piston, could be kept permanently hot, a fourth part of the heat which had been hitherto applied would be found to be sufficient to produce steam enough to fill it. How, then, was this desideratum to be attained? De Caus had proposed to effect the condensation of the steam by actually removing the furnace from under the boiler before every stroke of the piston; but this, in a working engine, evidently would have been found quite impracticable. Savery, the first who really constructed a working engine, and whose arrangements, as we have already remarked, all showed a very superior ingenuity, employed the method of throwing cold water over the outside of the vessel containing his steam—a perfectly manageable process, but at the same time a very wasteful one; inasmuch as every time it was repeated, it cooled not only the steam, but the vessel also, which, therefore, had again to be heated, by a large expenditure of fuel, before the steam could be reproduced. Newcomen's method of injecting the water into the cylinder was a considerable improvement on this; but it was still objectionable on the same ground, though not to the same degree; it still cooled not only the steam, on which it was desired to produce that effect, but also the cylinder itself, which, as the vessel in which more steam was to be

immediately manufactured, it was so important to keep hot. It was also a very serious objection to this last mentioned plan, that the injected water itself, from the heat of the place into which it was thrown, was very apt to be partly converted into steam; and the more cold water was used, the more considerable did this creation of new steam become. In fact, in the best of Newcomen's engines, the perfection of the vacuum was so greatly impaired from this cause, that the resistance experienced by the piston in its descent was found to amount to about a fourth part of the whole atmospheric pressure by which it was carried down, or, in other words, the working power of the machine was thereby diminished one fourth.

After reflecting for some time upon all this, it at last occurred to Watt to consider whether it might not be possible, instead of continuing to condense the steam in the cylinder, to contrive a method of drawing it off, to undergo that operation in some other vessel. This fortunate idea having presented itself to his thoughts, it was not very long before his ingenuity also suggested to him the means of realizing it. In the course of one or two days, according to his own account, he had all the necessary apparatus arranged in his mind. The plan which he devised, indeed, was an extremely simple one, and on that account the more beautiful. He proposed to establish a communication by an open pipe between the cylinder and another vessel, the consequence of which evidently would be, that when the steam was admitted into the former, it would flow into the latter so as to fill it also. If then the portion in this latter vessel only should be subjected to a condensing process, by being brought into contact with cold water, or any other convenient means, what would follow? Why, a vacuum would be produced here—into that, as a vent, more steam would immediately rush from the cylinder—that likewise would be condensed—and so the process would go on till all the steam had left the cylinder, and a perfect vacuum had been effected in that vessel, without so much as a drop of cold water having touched or entered it. The separate vessel alone, or the Condenser, as Watt called it, would be cooled by the water used to condense the steam—and that, instead of being an evil, manifestly tended to promote and quicken the condensation. When Watt reduced these views to the test of experiment, he found the result to answer his most sanguine expectations. The cylinder, although emptied of its steam for every stroke of the piston as before, was now constantly kept at the same temperature with the steam (or 212° Fahrenheit;) and the consequence was, that one fourth of the fuel formerly required sufficed to feed the engine.

But besides this most importan. saving in the expense of maintaining the engine, its power was greatly increased by the more perfect vacuum produced by the new construction, in which the condensing water, being no longer admitted within the cylinder, could not, as before, create new steam there while displacing the old. The first method which Watt adopted of cooling the steam in the condenser, was to keep that vessel surrounded by cold water—considering it as an objection to the admission of the water into its interior, that it might be difficult in that case to convey it away as fast as it would accumulate. But he found that the condensation was not effected in this manner with so much rapidity as was desirable. It was necessary for him, too, at any rate to employ a pump attached to the condenser, in order to draw off both the small quantity of water deposited by the cooled steam, and the air unavoidably introduced by the same element—either of which, if allowed to accumulate, would have impaired the perfect vacuum necessary to attract the steam from the cylinder. He therefore determined eventually to admit also the additional quantity of water required for the business of condensation, and merely to employ a larger and more powerful pump to carry off the whole.

Such, then, was the remedy by which the genius of this great inventor effectually cured the first and most serious defect of the old apparatus. In carrying his ideas into execution, he encountered, as was to be expected, many difficulties, arising principally from the impossibility of realizing theoretical perfection of structure with such materials as human art is obliged to work with; but his ingenuity and perseverance overcame every obstacle. One of the things which cost him the greatest trouble was, how to fit the piston so exactly to the cylinder as without affecting the freedom of its motion, to prevent the passage of the air between the two. In the old engine this end had been attained by covering the piston with a small quantity of water, the dripping down of which into the space below, where it merely mixed with the stream introduced to effect the condensation, was of little or no consequence. But in the new construction, the superiority of which consisted in keeping this receptacle for the steam always both hot and dry, such an effusion of moisture, although only in very small quantities, would have occasioned material inconvenience. The air alone, besides, which in the old engine followed the piston in its descent, acted with considerable effect in cooling the lower part of the cylinder. His attempts to overcome this difficulty, while they succeeded in that object, conducted Watt also to another improvement, which effected the complete removal

of what we have called the second radical imperfection of Newcomen's engine, namely, its non-employment, for a moving power, of the expansive force of the steam. The effectual way, it occurred to him, of preventing any air from escaping into the part of the cylinder below the piston, would be to dispense with the use of that element above the piston, and to substitute there likewise the same contrivance as below, of alternate steam and vacuum. This was of course to be accomplished by merely opening communications from the upper part of the cylinder to the boiler on the one hand, and the condenser on the other, and forming it at the same time into an air-tight chamber, by means of a cover, with only a hole in it to admit the rod or shank of the piston, which might besides, without impeding its freedom of action, be padded with hemp, the more completely to exclude the air. It was so contrived, accordingly, by a proper arrangement of the cocks and the machinery connected with them, that, while there was a vacuum in one end of the cylinder, there should be an admission of steam into the other; and the steam so admitted now served, not only, by its susceptibility of sudden condensation, to create the vacuum, but also, by its expansive force, to impel the piston. Steam, in fact, was now restored to be, what it had been in the early attempts to use it as a mechanical agent, the moving power of the engine; but its efficiency in this capacity was for the first time both taken full advantage of, by means of contrivances properly arranged for that end, and combined with, and aided by, its other equally valuable property which had alone been called into action in the more recent machines.

These were the great improvements which Watt introduced in what may be called the principle of the steam engine, or, in other words, in the manner of using and applying the steam. They constitute, therefore, the grounds of his claim to be regarded as the true author of the conquest that has at last been obtained by man over this powerful element. But original and comprehensive as were the views out of which these fundamental inventions arose, the exquisite and inexhaustible ingenuity which the engine, as finally perfected by him, displays in every part of its subordinate mechanism, is calculated to strike us perhaps with scarcely less admiration. It forms undoubtedly the best exemplification that has ever been afforded of the number and diversity of services which a piece of machinery may be made to render to itself by means solely of the various application of its first moving power, when that has once been called into action. Of these contrivances, however, we can only notice one or two, by way of specimen. Perhaps the most singular is that called the *governor*. This con

sists of an upright spindle, which is kept constantly turning, by being connected with a certain part of the machinery, and from which two balls are suspended in opposite directions by rods, attached by joints, somewhat in the manner of the legs of a pair tongs. As long as the motion of the engine is uniform, that of the spindle is so likewise, and the balls continue steadily revolving at the same distance from each other. But as soon as any alteration in the action of the piston takes place, the balls, if it has become more rapid, fly farther apart under the influence of the increased centrifugal force which actuates them—or approach nearer to each other in the opposite circumstances. This alone would have served to indicate the state of matters to the eye; but Watt was not to be satisfied. He connected the rods with a valve in the tube by which the steam is admitted to the cylinder from the boiler, in such a way that, as they retreat from each other, they gradually narrow the opening which is so guarded, or enlarge it as they tend to collapse; thus diminishing the supply of steam when the engine is going too fast, and, when it is not going fast enough, enabling it to regain its proper speed by allowing it an increase of aliment. Again, the constant supply of a sufficiency of water to the boiler is secured by an equally simple provision, namely, by a *float* resting on the surface of the water, which, as soon as it is carried down by the consumption of the water to a certain point, opens a valve and admits more. And so on through all the different parts of the apparatus, the various wonders of which cannot be better summed up than in the forcible and graphic language of a recent writer:—"In the present perfect state of the engine, it appears a thing almost endowed with intelligence. It regulates with perfect accuracy and uniformity the *number of its strokes* in a given time, *counting* or *recording* them moreover, to tell how much work it has done, as a clock records the beats of its pendulum; it regulates the *quantity of steam* admitted to work; the *briskness of the fire;* the *supply of water* to the boiler; the *supply of coals* to the fire; it *opens and shuts its valves* with absolute precision as to time and manner; it *oils its joints;* it *takes out any air* which may accidentally enter into parts which should be vacuous; and when any thing goes wrong which it cannot of itself rectify, it *warns its attendants* by ringing a bell; yet with all these talents and qualities, and eve when exerting the power of six hundred horses, it is obedient er the hand of a child; its aliment is coal, wood, charcoal, or ine. combustible,—it consumes none while idle,—it never tire xten- wants no sleep; it is not subject to malady when origin mposi- made, and only refuses to work when worn out with

equally active in all climates, and will do work of any kind; it is a water-pumper, a miner, a sailor, a cotton-spinner, a weaver, a blacksmith, a miller, &c. &c.; and a small engine, in the character of a *steam pony*, may be seen dragging after it, on a railroad, a hundred tons of merchandise, or a regiment of soldiers, with greater speed than that of our fleetest coaches. It is the king of machines, and a permanent realization of the *Genii* of eastern fable, whose supernatural powers were occasionally at the command of man."

In addition to those difficulties which his unrivalled mechanical ingenuity enabled him to surmount, Watt, notwithstanding the merit of his inventions, had to contend for some time with others of a different nature, in his attempts to reduce them to practice. He had no pecuniary resources of his own, and was at first without any friend willing to run the risk of the outlay necessary for an experiment on a sufficiently large scale. At last he applied to Dr. Roebuck, an ingenious and spirited speculator, who had just established the Carron iron-works, not far from Glasgow, and held also at this time a lease of the extensive coal-works at Kinneal, the property of the Duke of Hamilton. Dr. Roebuck agreed to advance the requisite funds on having two thirds of the profits made over to him; and upon this Mr. Watt took out his first patent in the beginning of the year 1769. An engine with a cylinder of eighteen inches diameter was soon after erected at Kinneal; and although, as a first experiment, it was necessarily in some respects of defective construction, its working completely demonstrated the great value of Watt's improvements. But Dr. Roebuck, whose undertakings were very numerous and various, in no long time after forming this connection, found himself involved in such pecuniary difficulties, as to put it out of his power to make any farther advances in prosecution of its object. On this, Watt employed himself for some years almost entirely to the ordinary work of his profession as a civil engineer; but at last, about the year 1774, when all hopes of any farther assistance from Dr. Roebuck were at an end, he resolved to close with a proposal which had been made to him through his friend Dr. Small, of Birmingham, that he should remove to that town, and enter into partnership with the eminent hardware manufacturer, Mr. Boulton, whose extensive [illegible]tablishment at Soho had already become famous over Europe, [illegible] procured for England an unrivalled reputation for the arts [illegible] carried on. Accordingly, an arrangement having been made [illegible]r. Roebuck, by which his share of the patent was transferred [illegible]Boulton, the firm of Boulton and Watt commenced the [illegible]f making steam engines in the year 1775.

Mr. Watt now obtained from parliament an extension of his patent for twenty-five years from this date, in consideration of the acknowledged national importance of his inventions. The first thing which he and his partner did, was to erect an engine at Soho, which they invited all persons interested in such machines to inspect. They then proposed to erect similar engines wherever required, on the very liberal principle of receiving as payment for each, only one third of the saving in fuel which it should effect, as compared with one of the old construction. As this saving, however, had been found to amount in the whole to fully three fourths of all the fuel that had been wont to be employed, the revenue thus accruing to the patentees became very great after their engines were extensively adopted. This they very soon were, especially in Cornwall, where the numerous mines afforded a vast field for the employment of the new power, partly in continuing or commencing works which only an economized expenditure could make profitable, and often also in labors which the old engine was altogether inadequate to attempt.

But the draining of mines was only one of many applications of the steam power now at his command which Watt contemplated, and in course of time accomplished. During the whole twenty-five years, indeed, over which his renewed patent extended, the perfecting of his invention was his chief occupation; and, notwithstanding a delicate state of health, and the depressing affliction of severe headaches to which he was extremely subject, he continued throughout this period to persevere with unwearied diligence in adding new improvements to the mechanism of the engine, and devising the means of applying it to new purposes of usefulness. He devoted, in particular, the exertions of many years to the contriving of the best methods of making the action of the piston communicate a rotary motion in various circumstances; and between the years 1781 and 1785 he took out four different patents for inventions having this object in view. In the midst of these scientific labors, too, his attention was much distracted by attempts which were made in several quarters to pirate his improvements, and the consequent necessity of defending his rights in a series of actions, which, notwithstanding successive verdicts in his favor, did not terminate till the year 1799, when the validity of his claims was finally confirmed by the unanimous decision of the Judges of the Court of King's Bench.

Watt's inexhaustible ingenuity displayed itself in various other contrivances besides those which make part of his steam engine. An apparatus for copying letters and other writings, now in extensive use; a method of heating houses by steam; a new composi-

tion, for the purposes of sculpture, having the transparency and nearly the hardness of marble; a machine for multiplying copies of busts and other performances in carving or statuary,—are enumerated among his minor inventions. But it is his steam-engine that forms the great monument of his genius, and that has conferred upon his name its imperishable renown. This invention has already gone far to revolutionize the whole domain of human industry; and almost every year is adding to its power and its conquests. In our manufactures, our arts, our commerce, our social accommodations, it is constantly achieving what, little more than half a century ago, would have been accounted miracles and impossibilities. "The trunk of an elephant, it has been finely and truly said, that can pick up a pin, or rend an oak, is as nothing to it. It can engrave a seal, and crush masses of obdurate metal like wax before it,—draw out, without breaking, a thread as fine as gossamer,—and lift a ship of war like a bauble in the air. It can embroider muslin and forge anchors; cut steal into ribbands, and impel loaded vessels against the fury of the winds and waves."

Locomotives, under the impetus communicated by this, the most potent, and at the same time the most perfectly controllable of all our mechanical agencies, have already been drawn forward at the flying speed of thirty and forty miles an hour. If so much has been done already, it would be rash to conclude that even this is to be our ultimate limit of attainment. In navigation, the resistance of the water, which increases rapidly as the force opposed to it increases, very soon sets bounds to the rate at which even the power of steam can impel a vessel forward. But, on land, the thin medium of the air presents no such insurmountable obstacle to a force making its way through it; and a rapidity of movement may perhaps be eventually attained here, which is to us even as yet inconceivable. But even when the rate of land travelling already shown to be quite practicable shall have become universal, in what a new state of society shall we find ourselves! When we shall be able to travel a hundred miles in any direction in six or eight hours, into what comparative neighborhood will the remotest extremes even of a large country be brought, and how little shall we think of what we now call *distance!* A nation will then be indeed a community; and all the benefits of the highest civilization, instead of being confined to one central spot, will be diffused equally over the land, like the light of heaven. This improvement, in short, when fully consummated, will confer upon man nearly as much new power and new enjoyment as if he were actually endowed with wings.

It is gratifying to reflect that even while he was yet alive, Watt

received from the voice of the most illustrious of his contemporaries the honors due to his genius. In 1785 he was elected a Fellow of the Royal Society; the degree of Doctor of Laws was conferred upon him by the University of Glasgow in 1806; and in 1808 he was elected a member of the French Institute. He died on the 25th of August, 1819, in the 84th year of his age.

We cannot better conclude our sketch of the life of this great inventor than by the following extract from the character that has been drawn of him by the eloquent writer, (Mr. Jeffrey,) whom we have already quoted. "Independently of his great attainments in mechanics, Mr. Watt was an extraordinary, and in many respects a wonderful man. Perhaps no individual in his age possessed so much and such varied and exact information,—had read so much, or remembered what he had read so accurately and well. He had infinite quickness of apprehension, a prodigious memory, and a certain rectifying and methodizing power of understanding, which extracted something precious out of all that was presented to it. His stores of miscellaneous knowledge were immense, and yet less astonishing than the command he had at all times over them. It seemed as if every subject that was casually started in conversation, had been that which he had been last occupied in studying and exhausting; such was the copiousness, the precision, and the admirable clearness of the information which he poured out upon it without effort or hesitation. Nor was this promptitude and compass of knowledge confined in any degree to the studies connected with his ordinary pursuits. That he should have been minutely and extensively skilled in chemistry and the arts, and in most of the branches of physical science, might perhaps have been conjectured; but it could not have been inferred from his usual occupations, and probably is not generally known, that he was curiously learned in many branches of antiquity, metaphysics, medicine, and etymology, and perfectly at home in all the details of architecture, music, and law. He was well acquainted, too, with most of the modern languages, and familiar with their most recent literature. Nor was it at all extraordinary to hear the great mechanician and engineer detailing and expounding, for hours together, the metaphysical theories of the German logicians, or criticising the measures or the matter of the German poetry.

"His astonishing memory was aided, no doubt, in a great measure, by a still higher and rarer faculty—by his power of digesting and arranging in its proper place all the information he received, and of casting aside and rejecting, as it were instinctively, whatever was worthless or immaterial. Every conception

that was suggested to his mind seemed instantly to take its place among its other rich furniture, and to be condensed into the smallest and most convenient form. He never appeared, therefore, to be at all encumbered or perplexed with the *verbiage* of the dull books he perused, or the idle talk to which he listened; but to have at once extracted, by a kind of intellectual alchemy, all that was worthy of attention, and to have reduced it for his own use to its true value and to its simplest form. And thus it often happened, that a great deal more was learned from his brief and vigorous account of the theories and arguments of tedious writers, than an ordinary student could ever have derived from the most faithful study of the originals, and that errors and absurdities became manifest from the mere clearness and plainness of his statement of them, which might have deluded and perplexed most of his hearers without that invaluable assistance."

JAMES BRINDLEY.

James Brindley, the celebrated engineer, was entirely self-taught in even the rudiments of mechanical science,—although, unfortunately, we are not in possession of any very minute details of the manner in which his powerful genius first found its way to the knowledge of those laws of nature of which it afterwards made so many admirable applications. He was born at Tunsted, in the parish of Wormhill, Derbyshire, in the year 1716; and all we know of the first seventeen years of his life is, that his father, having reduced himself to extreme poverty by his dissipated habits, he was allowed to grow up almost totally uneducated, and, from the time he was able to do any thing, was employed in the ordinary descriptions of country labor. To the end of his life this great genius was barely able to read on any very pressing occasion; for, generally speaking, he would no more have thought of looking into a book for any information he wanted, than of seeking for it in the heart of a millstone: and his knowledge of the art of writing hardly extended farther than the accomplishment of signing his name. It is probable, that as he grew towards manhood, he began to feel himself created for *higher things* than driving a cart or following a plough; and we may even venture to conjecture, that the particular bias of his genius towards mechanical invention had already disclosed itself, when,

at the age of seventeen, he bound himself apprentice to a person of the name of Bennet, a millwright, residing at Macclesfield, which was but a few miles from his native place. At all events, it is certain that he almost immediately displayed a wonderful natural aptitude for the profession he had chosen. "In the early part of his apprenticeship," says the writer of his life in the 'Biographia Britannica,' who was supplied with the materials of his article by Mr. Henshall, Brindley's brother-in-law, "he was frequently left by himself for whole weeks together, to execute works concerning which his master had given him no previous instructions. These works, therefore, he finished in his own way; and Mr. Bennet was often astonished at the improvements his apprentice from time to time introduced into the millwright business, and earnestly questioned him from whom he had gained his knowledge. He had not been long at the trade, before the millers, wherever he had been employed, always chose him again in preference to the master, or any other workman; and before the expiration of his servitude, at which time Mr. Bennet, who was advanced in years, grew unable to work, Mr. Brindley, by his ingenuity and application, kept up the business with credit, and even supported the old man and his family in a comfortable manner."

His master, indeed, from all that we hear of him, does not appear to have been very capable of teaching him much of any thing; and Brindley seems to have been left to pick up his knowledge of the business in the best way he could, by his own observation and sagacity. Bennet having been employed on one occasion, we are told, to build the machinery of a paper-mill, which he had never seen in his life, took a journey to a distant part of the country expressly for the purpose of inspecting one which might serve him for a model. However, he had made his observations, it would seem, to very little purpose; for, having returned home and fallen to work, he could make nothing of the business at all, and was only bewildering himself, when a stranger, who understood something of such matters, happening one day to see what he was about, felt no scruple in remarking in the neighborhood that the man was only throwing away his employer's money. The reports which in consequence got abroad soon reached the ears of Brindley, who had been employed on the machinery under the directions of his master. Having probably of himself begun ere this to suspect that all was not right, his suspicions were only confirmed by what he heard; but, aware how unlikely it was that his master would be able to explain matters, or even to assist him in getting out of his difficulties, he

did not apply to him. On the contrary, he said nothing to any one; but, waiting till the work of the week was over, set out by himself one Saturday evening to see the mill which his master had already visited. He accomplished his object, and was back to his work by Monday morning, having travelled the whole journey of fifty miles on foot. Perfectly master now of the construction of the mill, he found no difficulty in going on with his undertaking; and completed the machine, indeed, not only so as perfectly to satisfy the proprietor, but with several improvements on his model, of his own contrivance.

After remaining some years with Bennet, he set up in business for himself. With the reputation he had already acquired, his entire devotion to his profession, and the wonderful talent for mechanical invention, of which almost every piece of machinery he constructed gave evidence, he could not fail to succeed. But for some time, of course, he was known only in the neighborhood of the place where he lived. His connections, however, gradually became more and more extensive; and at length he began to undertake engineering in all its branches. He distinguished himself greatly in 1752, by the erection of a water-engine for draining a coal-mine at Clifton in Lancashire. The great difficulty in this case was to obtain a supply of water for working the engine; this he brought through a tunnel of six hundred yards in length, cut in the solid rock. It would appear, however, that his genius was not yet quite appreciated as it deserved to be, even by those who employed him. He was in some sort an intruder into his present profession, for which he had not been regularly educated; and it was natural enough that, before his great powers had had an opportunity of showing themselves, and commanding the universal admiration of those best qualified to judge of them, he should have been conceived by many to be rather a merely clever workman in a few particular departments, than one who could be safely intrusted with the entire management and superintendence of a complicated design. In 1755 it was determined to erect a new silk-mill at Congleton, in Cheshire; and another person having been appointed to preside over the execution of the work, and to arrange the more intricate combinations, Brindley was engaged to fabricate the larger wheels and other coarser parts of the apparatus. It soon became manifest, however, in this instance, that the superintendent was unfit for his office; and the proprietors were obliged to apply to Brindley to remedy several blunders into which he had fallen, and give his advice as to how the work should be proceeded in. Still they did not deem it proper to dismiss their incapable projector; but, the pressing difficulty overcome, would

have had him by whose ingenuity they had been enabled to get over it, to return to his subordinate place, and work under the directions of the same superior. This Brindley positively refused to do. He told them he was ready, if they would merely let him know what they wished the machine to perform, to apply his best endeavors to make it answer that purpose, and that he had no doubt he should succeed; but he would not submit to be superintended by a person whom he had discovered to be quite ignorant of the business he professed. This at once brought about a proper arrangement of matters. Brindley's services could not be dispensed with; those of the pretender, who had been set over him, might be so, without much disadvantage. The entire management of the work, therefore, was forthwith confined to the former, who completed it, with his usual ability, in a superior manner. He not only made important improvements, indeed, in many parts of the machine itself, but even in the mode of preparing the separate pieces of which it was to be composed. His ever-active genius was constantly displaying itself by the invention of the most beautiful and economical simplifications. One of these was a method which he contrived for cutting all his tooth and pinion wheels by machinery, instead of having them done by the hand, as they always till then had been. This invention enabled him to finish as much of that sort of work in one day as had formerly been accomplished in fourteen.

But the character of this man's mind was comprehensiveness and grandeur of conception; and he had not yet found any adequate field for the display of his vast ideas and almost inexhaustible powers of execution. Happily, however, this was at last afforded him, by the commencement of a series of undertakings in his native country, which deservedly rank among the achievements of modern enterprise and mechanical skill; and which were destined, within no long period, to change the whole aspect of the internal commerce of the island.

Artificial water-roads, or *canals*, were well known to the ancients. Without transcribing all the learning that has been collected upon the subject, and may be found in any of the common treatises, we may merely state that the Egyptians had early effected a junction, by this means, between the Red Sea and the Mediterranean; that both the Greeks and the Romans attempted to cut a canal across the Isthmus of Corinth; and that the latter people actually cut one in Britain from the neighborhood of Peterborough to that of Lincoln, some traces of which are still discernible. Canal navigation is also of considerable antiquity in China. The greatest work of this description in the world is the Imperial Canal

of that country, which is two hundred feet broad, and, commencing at Pekin, extends southward, to the distance of about nine hundred miles. It is supposed to have been constructed about eight centuries ago; but there are a great many smaller works of the same kind in the country, many of which are undoubtedly much older. The Chinese are unacquainted, as were also the ancients, with the contrivance called a lock, by means of which different levels are connected in modern canals, and which, as probably all our readers know, is merely a small intermediate space, in which the water can be kept at the same elevation as either part of the channel, into which the boat is admitted by the opening of one floodgate, and from which it is let out by the opening of another, after the former has been shut;—the purpose being thus attained, of floating it onwards, without any greater waste of water than the quantity required to alter the level of the enclosed space. When locks are not employed, the canal must be either of uniform level throughout, or it must consist of a succession of completely separated portions of water-way, from one to the other of which the boat is carried on an inclined plane, or by some other mechanical contrivance.

Canals have also been long in use in several of the countries of modern Europe, particularly in the Netherlands and in France. In the former, indeed, they constitute the principal means of communication between one place and another, whether for commercial or other purposes. In France, the canals of Burgundy, of Briare, of Orleans, and of Languedoc, all contribute important facilities to the commerce of the country. The last mentioned, which unites the Mediterranean to the Atlantic, is sixty feet broad and one hundred and fifty miles in length. It was finished in 1681; having employed twelve thousand men for fifteen years, and cost twelve hundred thousand pounds sterling.

It is remarkable that, with these examples before her, England was so late in availing herself of the advantages of canal navigation. The subject, however, had not been altogether unthought of. As early as the reign of Charles the Second, a scheme was in agitation for cutting a canal (which has since been made) between the Forth and the Clyde, in the northern part of the kingdom; but the idea was abandoned, from the difficulty of procuring the requisite funds. A very general impression, too, seems to have been felt, in the earlier part of the last century, as to the desirableness of effecting a canal navigation between the central English counties and either the metropolis or the eastern coast.

The first modern canal actually executed in England, was not begun till the year 1755. It was the result of a sudden thought

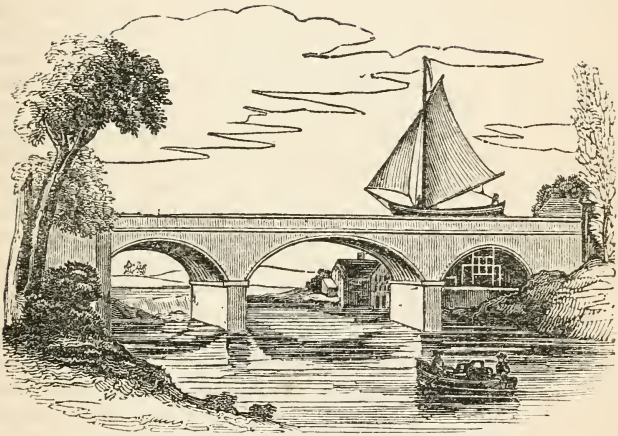
on the part of its undertakers, nothing of the kind having been contemplated by them when they commenced the operations which led to it. They had obtained an act of parliament for rendering navigable the Sankey brook, in Lancashire, which flows into the river Mersey, from the neighborhood of the now flourishing town of St. Helen's, through a district abounding in valuable beds of coal. Upon surveying the ground, however, with more care, it was considered better to leave the natural course of the stream altogether, and to carry the intended navigation along a new line, in other words, to cut a canal. The work was accordingly commenced; and the powers of the projectors having been enlarged by a second act of parliament, the canal was eventually extended to the length of about twelve miles. It has turned out both a highly successful speculation for the proprietors, and a valuble public accommodation.

It is probable that the Sankey Canal, although it did not give birth to the first idea of the great work we are now about to describe, had at least the honor of prompting the first decided step towards its execution. Francis, duke of Bridgewater, who, while yet much under age, had succeeded, in the year 1748, by the death of his elder brothers, to the family estates, and the title, which had been first borne by his father, had a property at Worsley, about seven miles west from Manchester, extremely rich in coal-mines, which, however, had hitherto been unproductive, owing to the want of any sufficiently economical means of transport. The object of supplying this defect had for some time strongly engaged the attention of the young duke, as it had, indeed, done that of his father; who, in the year 1732, had obtained an act of parliament enabling him to cut a canal to Manchester, but had been deterred from commencing the work, both by the immense pecuniary outlay which it would have demanded, and the formidable natural difficulties against which, at that time, there was probably no engineer in the country able to contend. When the idea, however, was now revived, the extraordinary mechanical genius of Brindley had already acquired for him an extensive reputation, and he was applied to by the duke, to survey the ground through which the proposed canal would have to be carried, and to make his report upon the practicability of the scheme. New as he was to this species of engineering, Brindley, confident in his own powers, at once undertook to make the desired examination, and, having finished it, expressed his conviction that the ground presented no difficulties which might not be surmounted. On receiving this assurance, the duke at once determined upon commencing the undertaking; and an act of parliament having been obtained in 1758, the powers of which were

considerably extended by succeeding acts, the formation of the canal was begun that year.

From the first, the duke resolved that, without regard to expense, every part of the work should be executed in the most perfect manner. One of the chief difficulties to be surmounted was that of procuring a sufficient supply of water; and, therefore, that there might be as little of it as possible wasted, it was determined that the canal should be of uniform level throughout, and of course without locks. It had consequently to be carried in various parts of its course both under hills and over wide and deep valleys. The point, indeed, from which it took its commencement was the heart of the coal mountain at Worsley. Here a large basin was formed, in the first place, from which a tunnel of three quarters of a mile in length had to be cut through the hill. We may just mention, in passing, that the subterraneous course of the water beyond this basin has since been extended in various directions for about thirty miles. After emerging from under ground, the line in the canal was carried forward, as we have stated, by the intrepid engineer, on the same undeviating level; every obstacle that presented itself being triumphed over by his admirable ingenuity, which the difficulties seemed only to render more fertile in happy inventions. Nor did his comprehensive mind ever neglect even the most subordinate departments of the enterprise. The operations of the workmen were every where facilitated by new machines of his contrivance; and whatever could contribute to the economy with which the work was carried on, was attended to only less anxiously than what was deemed essential to its completeness. Thus, for example, the materials excavated from one place were employed to form the necessary embankments at another, to which they were conveyed in boats, having bottoms which opened, and at once deposited the load in the place where it was wanted. No part of his task, indeed, seemed to meet this great engineer unprepared. He made no blunders, and never had either to undo any thing, or to wish it undone; on the contrary, when any new difficulty occurred, it appeared almost as if he had been all along providing for it—as if his other operations had been directed from the first by his anticipation of the one now about to be undertaken.

In order to bring the canal to Manchester it was necessary to carry it across the Irwell. That river is, and was then, navigable for a considerable way above the place at which the canal comes up to it; and this circumstance interposed an additional difficulty, as, of course, in establishing the one navigation, it was indispensable that the other should not be destroyed or interfered with. But nothing could dismay the daring genius of Brindley. Thinking it,



AQUEDUCT OVER THE IRWELL.

however, due to his noble employer to give him the most satisfying evidence in his power of the practicability of his design, he requested that another engineer might be called in to give his opinion before its execution should be determined on. This person Brindley carried to the spot where he proposed to rear his aqueduct, and endeavored to explain to him how he meant to carry on the work. But the man only shook his head, and remarked, that "*he had often heard of castles in the air, but never before was shown where any of them were to be erected.*" The duke, nevertheless, retained his confidence in his own engineer, and it was resolved that the work should proceed. The erection of the aqueduct, accordingly, was begun in September, 1760, and on the 17th of July following the first boat passed over it, the whole structure forming a bridge of above two hundred yards in length, supported upon three arches, of which the centre one rose nearly forty feet above the surface of the river; on which might be frequently beheld a vessel passing along, while another, with all its masts and sails standing, was holding its undisturbed way directly under its keel.

In 1762 an act of parliament was, after much opposition, obtained by the duke, for carrying a branch of his canal to communicate with Liverpool, and so uniting that town, by this method of communication, to Manchester. This portion of the canal, which is more than twenty-nine miles in length, is, like the former, without locks, and is carried by an aqueduct over the Mersey, the arch of which, however, is less lofty than that of the one over the Irwell, as the river is not navigable at the place where it crosses. It passes also over several valleys of considerable width and depth. Before this, the usual price of the carriage of goods between Liverpool and Manchester had been twelve shillings per ton by by water, and forty shillings by land; they were now conveyed by the canal, at a charge of six shillings per ton, and with all the regularity of land carriage.

In contemplating this great work, we ought not to overlook the admirable manner in which the enterprising nobleman, at whose expense it was undertaken, performed his part in carrying it on. It was his determination, as we have already stated, from the first, to spare no expense on its completion. Accordingly, he devoted to it during the time of its progress nearly the whole of his revenues, denying himself, all the while, even the ordinary accommodations of his rank, and living on an income of four hundred a year. He had even great commercial difficulties to contend with in the prosecution of his schemes, being at one time unable to raise 500*l.* on his bond on the Royal Exchange; and it was a chief business of his agent, Mr. Gilbert, to ride up and down the country to raise

money on his grace's promissory notes. It is true that he was afterwards amply repaid for this outlay and temporary sacrifice; but the compensation that eventually accrued to him he never might have lived to enjoy; and at all events he acted as none but extraordinary men do, in thus voluntarily relinquishing the present for the future, and preferring to any dissipation of his wealth on passing and merely personal objects, the creation of this magnificent monument of lasting public usefulness. Nor was it only in the liberality of his expenditure that the duke approved himself a patron worthy of Brindley. He supported his engineer throughout the undertaking with unflinching spirit, in the face of no little outcry and ridicule, to which the imagined extravagance or impracticability of many of his plans exposed him—and that even from those who were generally accounted the most scientific judges of such matters. The success with which these plans were carried into execution, is probably, in no slight degree, to be attributed to the perfect confidence with which their author was thus enabled to proceed.

While the Bridgewater canal was yet in progress, Mr. Brindley was engaged by Lord Gower, and the other principal landed proprietors of Staffordshire, to survey a line for another canal, which it was proposed should pass through that county, and, by uniting the Trent and the Mersey, open for it a communication, by water, with both the east and west coast. Having reported favorably of the practicability of this design, and an act of parliament having been obtained in 1765 for carrying it into effect, he was appointed to conduct the work. The scheme was one which had been often thought of; but the supposed impossibility of carrying the canal across the tract of elevated country which stretches along the central region of England had hitherto prevented any attempt to execute it. This was, however, precisely such an obstacle as Brindley delighted to cope with; and he at once overcame it, by carrying a tunnel through Harecastle Hill, of two thousand eight hundred and eighty yards in length, at a depth, in some places, of more than two hundred feet below the surface of the earth. This was only one of five tunnels excavated in different parts of the canal, which extends to the length of ninety-three miles, having seventy-six locks, and passing in its course over many aqueducts. Brindley, however, did not live to execute the whole of this great work, which was finished by his brother-in-law, Mr. Henshall, in 1777, about eleven years after its commencement.

During the time that these operations, so new in England, were in progress, the curious crowded to witness them from all quarters, and the grandeur of many of Brindley's plans seems to have made a deep impression upon even his unscientific visiters.

A letter which appeared in the newspapers, while he was engaged with the Trent and Mersey Canal, gives us a lively picture of the astonishment with which the multitude viewed what he was about. The writer, it will be observed, alludes particularly to the Harecastle tunnel, the chief difficulty in excavating which arose from the nature of the soil it had to be cut through. "Gentlemen come to view our eighth wonder of the world, the subterranean navigation which is cutting by the great Mr. Brindley, who handles rocks as easily as you would plum-pies, and makes the four elements subservient to his will. He is as plain a looking man as one of the boors of the Peak, or one of his own carters; but when he speaks all ears listen, and every mind is filled with wonder at the things he pronounces to be practicable. He has cut a mile through bogs which he binds up, embanking them with stones, which he gets out of other parts of the navigation, besides about a quarter of a mile into the hill Yelden, on the side of which he has a pump, which is worked by water, and a stove, the fire of which sucks through a pipe the damps that would annoy the men who are cutting towards the centre of the hill. The clay he cuts out serves for brick to arch the subterraneous part, which we heartily wish to see finished to Wilden Ferry, when we shall be able to send coals and pots to London, and to different parts of the globe."

It would occupy too much of our space to detail, however rapidly, the history of the other undertakings of this description to which the remainder of Mr. Brindley's life was devoted. The success with which the Duke of Bridgewater's enterprising plans for the improvement of his property were rewarded, speedily prompted numerous other speculations of a similar description; and many canals were formed in different parts of the kingdom, in the execution or planning of almost all of which Brindley's services were employed. He himself had become quite an enthusiast in his new profession, as a little anecdote that has been often told of him may serve to show. Having been called on one occasion to give his evidence touching some professional point before a committee of the house of commons, he expressed himself, in the course of his examination, with so much contempt of rivers as means of internal navigation, that an honorable member was tempted to ask him for what purpose he conceived rivers to have been created? when Brindley, after hesitating a moment, replied, "*To feed canals.*" His success as a builder of aqueducts would appear to have inspired him with almost as fervid a zeal in favor of bridges as of canals, if it be true, as has been asserted, that one of his favorite schemes contemplated the joining of Great Britain to Ireland by a bridge of boats extending from Port Patrick to Donag

hadee. This report, however, is alleged to be without foundation by the late Earl of Bridgewater, in a curious work which he published some years ago at Paris, relative to his predecessor's celebrated canal.

Brindley's multiplied labors, and intense application, rapidly wasted his strength, and shortened his life. He died at Turnhurst, in Staffordshire, on the 27th of September, 1772, in the fifty-sixth year of his age, having suffered for some years under a hectic fever, which he had never been able to get rid of. In his case, as in that of other active spirits, the soul seems to have

"O'er-inform'd its tenement of clay;"

although the actual bodily fatigue to which his many engagements subjected him, must doubtless have contributed to wear him out.

No man ever lived more for his pursuit, or less for himself, than Brindley. He had no sources of enjoyment, or even of thought, except in his profession. It is related, that having once, when in London, been prevailed upon to go to the theatre, the unusual excitement so confused and agitated him, as actually to unfit him for business for several days, on which account he never could be induced to repeat his visit. His total want of education, and ignorance of literature, left his genius without any other field in which to exercise itself and spend its strength than that which the pursuit of his profession afforded it: its power, even here, would not probably have been impaired, if it could have better sought relaxation in variety; on the contrary, its spring would most likely have been all the stronger for being occasionally unbent. We have already mentioned that he was all but entirely ignorant of reading and writing. He knew something of figures, but did not avail himself much of their assistance in performing the calculations which were frequently necessary in the prosecution of his mechanical designs. On these occasions his habit was to work the question by a method of his own, chiefly in his head, only setting down the results at particular stages of the operation; yet his conclusions were generally correct. His vigor of conception, in regard to machinery, was so great, that however complicated might be the machine he had to execute, he never, except sometimes to satisfy his employers, made any drawing or model of it; but having once fixed its different parts in his mind, would construct it without any difficulty, merely from the idea of which he had thus possessed himself. When much perplexed with any problem he had to solve, his practice was to take to bed, in order to study it; and he would sometimes remain, we are told, for two or three days thus fixed to his pillow in meditation.

Had it not been for the example set by his adventurous genius, the progress of artificial navigation in Great Britain would probably have been timid and slow, compared to what it has been. For a long time, in all likelihood, the only canals would have been a few small ones, cut in the more level parts of the country, the benefit of each of which would have been extremely insignificant, and confined to a very narrow neighborhood. He did, in the very infancy of the art, what has not yet been outdone; struggling, indeed, with such difficulties, and triumphing over them, as could be scarcely exceeded by any his successors might have to encounter. By the boldness and success with which, in particular, he carried the grand Trunk Navigation across the elevated ground of the midland counties, he demonstrated that there was hardly any part of the island where a canal might not be formed; and, accordingly, this very central ridge, which used to be deemed so insurmountable an obstacle to the junction of the opposite coasts, is now intersected by more than twenty canals besides the one which he first drove through the barrier. It is in the conception and accomplishment of such grand and fortunate deviations from ordinary practice that we discern the power, and confess the value, of original genius.

The case of Brindley affords us a wonderful example of what the force of natural talent will sometimes do in attaining an acquaintance with particular departments of science, in the face of almost every conceivable disadvantage—where not only all education is wanting, but even all access to books.

JESSE RAMSDEN.

Jesse Ramsden was born in 1735, at Salterhebble, near Halifax, where his father kept an inn. The education he received in his boyhood embraced both a little Latin and the elements of geometry and algebra. But when he was of the usual age for being put to a business, his father took him from school, and bound him apprentice to a clothier in Halifax; and in this line he continued till he reached his twentieth year, when he came up to London, and obtained employment as a clerk in a wholesale warehouse. He held this situation for about two years and a half; but in the mean time he had industriously availed himself of what leisure he could command to renew and extend his acquaintance

with science; and so enamoured did he gradually become of these pursuits, that he at last resolved to make an effort to establish himself in some line more closely connected with his favorite studies than that which he had heretofore followed. With this view, notwithstanding that he was now so far beyond the age at which the learning of a business is usually begun, he bound himself apprentice for four years to Mr. Burton, of Denmark-court, a mathematical instrument maker. On the expiration of this term, he and a fellow-workman of the name of Cole entered into business together, Ramsden serving the other as journeyman at a salary of twelve shillings per week. This connection, however, did not last long; and on its termination Ramsden opened a shop of his own. His chief employment for some time consisted in repairing optical and other mathematical instruments which had got out of order; and in this the industry and ability he displayed soon brought him into notice, and procured him a rapidly increasing business. But he did not rest satisfied with merely performing in a superior manner such work as he undertook of this description; the different instruments which passed through his hands forcibly attracted his attention to the imperfections by which each happened to be characterized, and called his powers of contrivance into exercise in devising how they might be improved. In order to accomplish himself the more completely for this task, he labored assiduously till he acquired, entirely by his own application, the art of grinding glass, and of handling the file, the lathe, and the other instruments used by opticians. Thus furnished with the practical skill and dexterity requisite to enable him to apply his ingenuity and mathematical knowledge, he proceeded to enter upon a regular and comprehensive examination of all the different optical instruments in use, with a view to the remedying of their several defects.

This resolution, and the perseverance with which it was followed up, eventually made Ramsden one of the greatest optical mechanicians that the world has ever produced. The list of the instruments which are indebted to him for the most ingenious and valuable improvements, embraces nearly all those of greatest importance and most common use in astronomy and the connected sciences. Hadley's quadrant, the sextant, the theodolite, the barometer, the transit instrument, and many others too numerous to specify, all came out of his hands, it might almost be said, with new powers, and certainly, at all events, with much more in every case than they before possessed, both of manageableness and of accuracy. In this last respect, especially, the instruments constructed by him far surpassed any that had before been produced;

and they were indebted for much of their superiority to a new dividing or graduating engine which he had contrived, the principle of which was extremely ingenious. It consisted essentially of a marker moved forward by the turning of a very fine-threaded screw. It is easy to make a screw with a hundred turns of the thread in an inch; and by attaching to it a handle or index of sufficient length, so that the extremity may be over a properly divided circle of considerable magnitude, the movement of such a screw may be regulated with perfect precision to the thousandth part of one of its entire revolutions. Now, as by such a revolution it would only advance the marker the hundredth part of an inch, it is evident that, by being turned only the thousandth part of an entire revolution every time the marker is allowed to descend and make an impression upon the plate of metal or other surface to be divided, a hundred thousand equidistant lines may actually be drawn upon every inch of that surface. For this most useful contrivance the Board of Longitude awarded him a premium of £615; and in return he engaged to graduate whatever sextants were put into his hands for that purpose, at the rate of three shillings a-piece. His engine, indeed, enabled him to perform the operation in about twenty minutes, whereas it had been wont to occupy many hours. But the additional accuracy which was given to the instrument to which it was applied by the new method, was of still greater importance than its comparative expedition and cheapness. Hadley's quadrant, for instance, used to be so coarsely divided, and in other respects so defectively made, before it received Ramsden's improvements, that, in endeavoring to ascertain the longitude by it, the observation might in some cases lead to an error of fifty leagues; but Ramsden constructed it in so superior a manner, that even his commonest instruments did not admit of an error being fallen into of more than the tenth part of that amount, and with those of a more expensive description accuracy was ensured in all cases to within a single league.

Soon after he commenced business, Ramsden married Miss Dollond, daughter of the inventor of the achromatic telescope, part of the patent for which came in this way into his possession. In 1786 he was elected a Fellow of the Royal Society, having been proposed by his friends without his knowledge, after his diffidence in his claims to such a distinction had made him long withhold his consent to their taking that step. In 1794 he was chosen a member of the Imperial Academy of Sciences at Petersburg; and in 1795 the Royal Society awarded him the gold medal annually bestowed by them for eminence in science.

The Reverend Lewis Dutens, the author of the "Researches on

the Origin of Discoveries," who was intimately acquainted with Ramsden, has given us an account of his friend, which contains some interesting particulars of his character and habits. After noticing his great activity, the uncommon force of his reasoning powers, and the accurate and retentive memory with which he was endowed, the writer proceeds to remark, that perhaps, after all, the most distinguishing quality of his mind was a certain elegance, and taste for precision and high finish, which appeared not more in the instruments he manufactured than in every thing he did. "This feeling for perfection," Mr. Dutens goes on to say, "led him, in the most minute and insignificant parts of his instruments, to a polish and grace, which sometimes tempted those to smile who did not perceive that the same principle which enabled him to carry the essential parts of his instruments to a degree of perfection unknown, and considered as impossible before his time, induced him to be dissatisfied if a blemish of any sort, even the most trifling, appeared to his exquisite eye. To these uncommonly strong natural endowments he added all that the most constant and intense study could bestow. Temperate to abstemiousness in his diet, satisfied with an extremely small portion of sleep, unacquainted with dissipation or amusement, and giving but very little time even to the society of his friends, the whole of those hours which he could spare from the duties of his profession were devoted either to meditation on farther improvements of philosophical instruments, or to the perusal of books of science, particularly those mathematical works of the most sublime writers which had any connection with the subjects of his own pursuits. Mr. Ramsden's only relaxation from these constant and severe studies was the occasional perusal of the best authors both in prose and verse; and when it is recollected that at an advanced age he made himself so completely master of the French language as to read with peculiar pleasure the works of Boileau and Moliere, he will not be accused of trifling even in his lighter hours. Short and temperate as were his repasts, a book or a pen were the constant companions of his meals, and not seldom brought on a forgetfulness of hunger; and when illness broke his sleep, a lamp and a book were ever in readiness to beguile the sense of pain, and make bodily sickness minister to the progress of his mind. Of the extent of his mathematical knowledge he was always from innate modesty averse to speak, although I have heard him say that he never was at a loss when his profession required the application of geometry. His knowledge in the science of optics is well known to have been perfect; and when we add that the works of Bouguer and the great Leonard Euler were his favorite study

we shall not lightly rate his proficiency in mathematics. Of his skill in mechanics it is unnecessary to speak. Nor let it be supposed that his science in his profession was limited to the higher branch of invention and direction of the labors of others. It is a well-known fact, that such was his own manual dexterity, that there was not any one tool, in any of the numerous branches of his profession, which he could not use with a degree of perfection at least equal to that of the very best workman in that particular branch; and it is no exaggeration to assert that he could with his own hands have begun and finished every single part of his most complicated instruments. It may not be foreign to this part of his character to observe, that his drawings were singularly neat and accurate, and his handwriting so beautiful, that when he chose to exert his skill few writing-masters could equal it."

In order to ensure that perfect accuracy which it was his object to give to every instrument he sold, Ramsden had all the parts of the work done under his own inspection; and for this purpose he kept men of every necessary branch of trade in his establishment. He availed himself also to the utmost of the advantages to be derived from the division of labor—allotting to every workman his particular department, from which he was never called away to another. He employed about sixty men in all; but such was his reputation over all Europe, and so numerous were the orders he received, that even with this large establishment he found it impossible to execute them with the requisite expedition. About this, indeed, he did not give himself much trouble; what alone he cared for was, that every instrument which bore his name should be worthy of his reputation, no matter what time or pains it should cost to make it so. No man was ever more nobly indifferent to the mere pecuniary gains of his art. If he had been anxious to enrich himself, he might have easily accumulated a large fortune; but for that object he would have had to enlarge his already extensive establishment so much farther, that his personal superintendence of every part of it would have been impossible. So far was he from being influenced by any views of this kind, that it is asserted he never executed any one of the many great works for which he received commissions from public bodies, both in his own and other countries, without being a loser by it as a tradesman. When he occasionally sent for a workman to give him necessary directions concerning what he wished to have done, he first showed the recent finished plan, then explained the different parts of it, and generally concluded by saying, with the greatest good-humour, "*Now see, man, let us try to find fault with it;*" and thus, by putting two heads together to scrutinize his own perform-

ance, some alteration was probably made for the better. But, whatever expense an instrument had cost in forming, if it did not fully answer the intended design, he would immediately say, after a little examination of the work, "*Bobs, man! this won't do; we must have at it again;*" and when it did not answer his expectations, he never hesitated to take it to pieces, or to destroy it, whatever had been the cost bestowed upon its construction. Admirable as all his instruments were, too, for their accuracy, their high finish, their durability, and all the other qualities that make up the excellence of such productions, he generally put a less price upon them—in some cases a much less price—than was charged for inferior works of the same kind by other artists.

It was his custom to retire in the evening to what he considered the most comfortable corner in the house, viz., the kitchen fireside, in order to draw some plan for the forming of some new instrument, or perfecting one already made. There he sat, with his drawing implements on the table before him, a cat sitting on the one side, and a certain portion of bread, butter, and a small mug of porter, placed on the other side, while four or five apprentices commonly made up the circle. He amused himself with either whistling the favorite air, or sometimes singing the old ballad, of

> "If she is not so true to me,
> What care I to whom she be:
> What care I, what care I to whom she be!"

and appeared in this domestic group contented and happy.

Mr. Ramsden died on the 5th of November, 1800, at Brighton, to which place he had gone a short time before with the view of recovering his health, which, never vigorous, had latterly been greatly impaired by his unremitting exertions. He died possessed of only a small fortune; and, in the spirit in which he had lived, he left the greater part of it to be divided among his workmen, in proportion to their merits and their length of service.

EARL OF STANHOPE.

This eccentric and ingenious nobleman was born at Chevening, Kent, in August, 1753. In his 9th year he was sent to Eton, and at this early age began to give strong proofs of his mechanical and mathematical taste. In his ninteenth year he was removed to Geneva, and placed under the tuition of Le Sage; and a few

months afterwards, he gained a prize, offered by a national academy for the best paper written in French, on the construction of the pendulum.

The earl was the author of a great number of inventions and improvements in the arts and philosophy. Among those which attracted the most attention were his electrical experiments; his scheme for securing buildings from fire; a machine for solving problems in arithmetic; a mode of roofing houses; a kiln for burning lime,—a steamboat,—and a double inclined plane for remedying the inconvenience attending canal locks. This was suggested to the earl while he was forming a canal in Devonshire, the line of which he surveyed himself; and during this employment, he for days carried the theodolite on his own shoulders. Experiments on stereotype printing,—an esteemed printing press which bears his name,—a plan for preventing forgeries in coin and bank notes, &c. &c. In putting his ideas into practice he was assisted by Mr. Varley, one of the most expert practical mechanics of the day.

But numerous and important as his labors were to the arts, they were, even in a public view, exceeded in importance by the impulse which his patronage gave to mechanical artists. He appeared to be delighted in bringing them and their productions before the public, and in this way he spent a large portion of his ample fortune, and almost the whole of his thoughts and time.

Whatever view different men might take of the soundness or tendency of his political principles, all were convinced that they sprang from the honest conviction of his own mind, uninfluenced by the most remotely interested motive, for he uniformly declined all offices and public honors. If his projects, both political and mechanical, were occasionally considered impracticable, they were neither sordid nor selfish.

His speeches in the house of lords, and in public, on whatever topic, were ingenuous, perspicuous, and somewhat forcible. But it was often as difficult to answer as to concur with them;—for he seldom adapted his opinions to the state of public affairs, but reasoned from some abstract standard of moral or political right, that was seldom in accordance with principles of party or state expediency. He was sometimes eloquent, and at others, very eccentric in his illustrations. There was often a certain quaintness of manner about them that made them quite irresistible, even to producing laughter, from the guarded and studied gravity of the incumbent on the woolsack.

His activity and perseverance were amazing, for notwithstanding the multiplicity of his projects and experiments, he was assuredly

profoundly learned in every thing that regarded the constitution and ecclesiastical polity of his country, and when on these subjects, it is said he even taught "*the Judges law, and the Bishops religion!*"—When questions arose which required a practical knowledge of the exact sciences, or their application to the arts, if he were not the only man, he was, at least, the ablest in the house to expound, discuss, and decide them: and on such occasions he ever acted with great judgment.

Earl Stanhope married Hester Pitt, a daughter of the great Earl of Chatham, whose political principles he venerated with a feeling little removed from idolatry; and in the early part of his public career, acted cordially with his brother-in-law Mr. Pitt. But the circumstances which induced that consummate statesman to alter his opinions, had not the same effect on the earl, and their political connection was dissolved. On this separation taking place, a domestic difficulty sprung up between Stanhope, and his wife and wife's connections. This dissension arose from the fact, that Stanhope desired that *his* children should devote themselves to *acquire some useful calling as he had done*, by which, when the day of public calamity came, which he imagined he foresaw the rapid approach of,—they might secure independence by their own personal ingenuity and labor. But his family preferring the patronage of their uncle, the minister, to the protection of the paternal roof, Stanhope declared as they chose to be saddled on the public purse, they must "*take the consequences.*" They were not therefore mentioned in his will, although they were entitled to certain sums by a marriage settlement.

"Charles Stanhope," said the Earl of Chatham, "as a carpenter, a blacksmith, or millwright, could in any country, or any times, preserve his independence and bring up his family in honest and industrious courses, without soliciting the bounty of friends or the charity of strangers."

Stanhope was odd in his dress and person, and his plain, unaffected, amiable manners, were considered to be singular for a man of his high rank and connections: but they conciliated affection in many cases approaching to devotion, and his general integrity commanded universal respect. He was a considerate and kind landlord, an ardent friend, and his purse and influence were ever open to befriend the helpless and the poor; but he always disliked any superfluous expressions of gratitude.

Among other anecdotes of his lordship's eccentricities, the following is related. He was very particular in the shape and texture of his wigs, which were peculiar, and was a long time in getting a barber to make them to his liking, but at last succeeded. It

happened, however, that at a period when his stock of these "elegant imitations of nature" was "unusually low," the poor barber was taken so exceedingly ill that his life was despaired of. His lordship immediately on hearing of the illness of his favorite artist, sent a physician to attend him, and the first desire of the barber on his recovery was, very naturally, to assure the noble lord of his gratitude for this unexpected act of benevolence. After a few words of condolence, his lordship asked him if his funds were not exhausted by his long inability to attend to his business, and whether an order in the *way of trade* would not be serviceable to him. Receiving an answer in the affirmative, he ordered a score of wigs. Upon bringing them home, the wig maker began to pour forth the grateful feelings of his heart for this new kindness, in addition to having saved his life, when his lordship interrupted him by putting down the money, and jokingly remarked, "Oh!—you may now die and be —— for aught I care, for I have got *wigs enough to last all my life!*"

Lord Stanhope died in December, 1815, deeply lamented by all, but more especially by the humbler class of citizens, whose esteem and friendship he had won by his interest and exertions in their welfare.

HOHLFELD.

HOHLFELD, the celebrated German mechanic, was born of poor parents at Hennerndorf, in the mountains of Saxony, in the year 1711. He learned the trade of lace-making at Dresden, and early disovered a turn for mechanics by constructing various kinds of clocks. From Dresden he removed to Berlin to follow his occupation. As he was an excellent workman, and had invented several machines for shortening his labor, he found sufficient time to indulge his inclination for mechanics; and he made there, at the same time he pursued his usual business, air-guns and clocks. In the year 1748, he became acquainted with the celebrated Sulzer, at whose desire he undertook the construction of a machine for noting down any piece of music when played upon a harpsichord A machine of this kind had been before invented by Mr. Von Unger, but Hohlfeld, from a very imperfect description, completed one without any assistance. Of this machine, now in the possession of the Academy of Sciences at Berlin, Sulzer gave a figure, from which it was afterwards constructed in England. This ingenious

piece of mechanism was universally approved, though several things may be wanting to render it complete; but no one was so generous as to indemnify the artist for his expenses, or to reward him for his labor.

About the year 1756, the Prussian minister, Count de Powdewils, took him into his service, chiefly for the purpose of constructing water-works in his magnificent gardens at Gusow. There he invented his well-known threshing machine, and another for chopping straw more expeditiously. He also displayed his talent for invention by constructing an apparatus which, when fastened to a carriage, indicated the number of revolutions made by the wheels. Such machines had been made before, but his far exceeded every thing of the like kind. Having lost this machine by a fire, he invented another still simpler, which was so contrived as to be buckled between the spokes of the wheel. This piece of mechanism was in the possession of Sulzer, who used it on his tour, and found that it answered the intended purpose.

In the year 1765, when the Duke of Courland, then hereditary prince, resided at Berlin, he paid a visit to Hohlfeld and endeavored to prevail on him to go to Courland, by offering him a pension of eight hundred rix-dollars; but this ingenious man was so contented with his condition, and so attached to his friends, that he would not, merely for self-interest, quit Berlin. His refusal, however, obtained for him a pension of one hundred and fifty dollars from the king. Besides the before mentioned machines, he constructed occasionally several useful models. Among these was a loom for weaving figured stuffs, so contrived that the weaver had no need of any thing to shoot through the woof; a pedometer for putting in the pocket; a convenient and simple bed for a sick person, by which the patient could at any time, with the least effort, raise or lower the breast, and, when necessary, convert the bed into a stool; and a carriage, so formed, that if the horses took fright and ran away, the person in it could, by a single push, loosen the pole and set them at liberty.

Every machine that this singular man saw, he altered and improved in the simplest manner. All his own instruments he made himself, and repaired them when damaged. But as he was fonder of inventing than of following the plans of others, he made them in such a way that no one but himself could use them. Several of his improvements were, however, imitated by common workmen, though in a very clumsy manner. It is worthy of remark, that he never bestowed study upon any thing; but when he had once conceived an idea, he immediately executed it. He comprehended in a moment whatever was proposed, and at the same time

saw how it was to be accomplished. He could, therefore, tell in an instant whether a thing was practicable; if he thought it was not, no persuasion or offer of money could induce him to attempt it. He never pursued chimeras, like those mechanics who have not had the benefit of education or instruction; and though this may be ascribed to the intercourse he had with great mathematicians and philosophers, there is every reason to believe that he would have equally guarded himself against them, even had he not enjoyed that advantage.

The same quickness of apprehension which he manifested in mechanics, he showed also in other things. His observations on most subjects were judicious, and peculiar to himself. With regard to his moral character, he was every thing that could be desired. Although he still retained something of the manners of his former condition, his mild and pleasing deportment rendered his company and conversation agreeable. He possessed a good heart, and his life was sober and regular. Though he was every day welcome to the best tables, he stayed for the most part at home through choice; went to market for his own provisions, which he cooked himself, and was as contented over his humble meal as Curius was over his turnips. A little before his death he had the pleasure of seeing a curious harpsichord he had made, and which was purchased by his Prussian majesty, placed in an elegant apartment of the new palace at Pottsdam. As he had for some time neglected this instrument, the too great attention which he bestowed on putting it in order, contributed not a little to bring on that disease which at last proved fatal to him. His clock having become deranged during his illness, he could not be prevented, notwithstanding the admonition and advice of his friend and physician, Dr. Stahls, from repairing it. Close application occasioned some obstructions which were not observed till too late; and an inflammation taking place, he died, in 1771, at the house of Count de Powdewils, in the sixtieth year of his age.

MATTHEW BOULTON.

This individual, well known as the partner of the celebrated Watt, was born at Birmingham on the 14th of September, 1728; and after having received a tolerable education, studied drawing and mathematics. He commenced business as a manufacturer of

hardware; and having discovered a new method of inlaying steel, he sent a considerable quantity of buckles, watch-chains, &c., to the continent, where they were purchased by the English travellers as the offspring of French ingenuity. Finding his premises at Birmingham not sufficiently capacious for his purposes, he, in 1762, purchased an extensive tract of heath, about two miles from the town, and at great expense laid the foundation of those vast and unrivalled works known as the Soho establishment. To this spot his liberality soon attracted numbers of ingenious men from all parts, and by their aid the most splendid apartments in Europe received their ornaments.

About 1767, finding the force of the water-mill inadequate to his purposes, he constructed a steam engine upon the original plan of Savery; and two years afterwards entered into partnership with Watt, in conjunction with whom he turned that machine into several new and important uses. They soon acquired a mechanical fame all over Europe by the extent and utility of their undertakings; the most important of which was their improvement in coinage, which they effected about 1788. The coins struck at the Soho manufactory were remarkable for their beauty and execution, and caused the inventors to be employed by the Sierra Leone Company in the coinage of their silver, and by the East India Company in that of their copper.

Mr. Boulton also sent two complete mints to St. Petersburg; and having presented the late emperor Paul the First with some of the most curious articles of his manufacture, that sovereign returned him a polite letter of thanks and approbation, together with a princely present of medals and minerals from Siberia, and specimens of all the modern money of Russia. Another invention which emanated from the Soho establishment was a method of copying oil paintings with such fidelity as to deceive the most practised connoisseurs. The last discovery for which Mr. Boulton obtained a patent, was an important method for raising water and other fluids by impulse; the specification of which is published in the ninth volume of the Repertory of the Arts. It had been demonstrated by Daniel Bernouilli, that water flowing through a pipe and arriving at a part in which the pipe is suddenly contracted, would have its velocity at first very greatly increased; but no practical application of the principle appears to have been attempted until 1792, by an apparatus set up by Mr. Whitehurst at Oulton, in Cheshire. To this Mr. Boulton added a number of ingenious modifications.

As an illustration of the nicety and skill displayed in some of the articles made by Mr. Boulton, the following anecdote is re-

iated :—He visited France on a certain occasion, for the purpose of attending a celebrated mechanical fair that was about taking place; at which he begged to be allowed to exhibit a needle of his own making, at the same time submitting it to the examiners of works intended for this public display, who one and all pronounced it to be, though well-shaped and finely polished, but a "*common needle*," and not worthy of appearing amongst the splendid and ingenious improvements and inventions that usually graced the fair. "Gentlemen," observed Mr. Boulton, "my needle is well worthy of appearance amongst your promised novelties; only allow it to be exhibited with them now, and I will afterwards show you the reason why."

An unwilling assent to this request was finally obtained; but when the fair closed, and the prizes were to be awarded, the arbitrators triumphantly asked, "where was Mr. Boulton's needle? and what were those striking merits which everybody had failed to discover?" Thereupon Mr. Boulton again presented it to them for inspection, with a magnifying glass, begging them to state whether they observed roughness or wrinkle upon its surface. The umpires returning it, said, "Far from it; for that its sole merit seemed to lie in its exquisite polish." "Behold, then," said this ingenious man, "its undiscoverable merit; and whilst I prove to you that I made no vain boast of its claim to your attention, you will learn, perhaps, not to judge so readily again by mere exterior." He then unscrewed the needle, when another appeared of as exquisite a workmanship; and, to the astonished eyes of the Frenchmen, about half a dozen beautiful needles were thus turned out, neatly and curiously packed within each other!—a miracle of art that seems to rival all we ever read of,—a truly "multum in parvo!" Mr. Boulton triumphed in his turn, and carried off the prize which his delicate workmanship so richly deserved.

Mr. Boulton appeared at St. James' on a levee day: "Well, Mr. Boulton," said the king, "I am glad to see you; what new project have you got now?" "I am," said Mr. Boulton, "manufacturing a new article that kings are very fond of." "Aye! aye! Mr. Boulton, what's that?" "It is power, and please your majesty." "Power!—Mr. Boulton, we like *power*, that's true; but what do you mean?" "Why, sir, I mean the power of *steam* to move machines." His majesty appeared pleased, and laughing, said, "Very good; go on, go on."

After a life devoted to the advancement of the useful arts and the commercial interests of his country, the subject of our memoir died on the 17th of August, 1809, in the eighty-first year of his

age, and was buried at Handsworth, near Soho; his funeral being followed by six hundred workmen, each of whom received a silver medal, struck to commemorate the event.

Mr. Boulton presents us with an example of the vast influence and effects that may be produced upon society by the well-directed powers of a great mind abundantly stored with resources, but disdaining the selfish and narrow views that might have contracted its usefulness, had he neglected to call to his aid the genius of a Watt, and others equally eminent in their spheres. His private character was very amiable; and in his manners and conversation he is said to have been extremely fascinating.

THOMAS TELFORD.

It is to the energies of genius in humble life that science is chiefly indebted for its most valuable discoveries, and extension of its empire. The names of Brindley, Watt, and Arkwright will never be forgotten; and with them, and others equally distinguished, will henceforth rank Telford, a civil engineer, and constructor of public works, unsurpassed in any country.

Thomas Telford was born in the year 1757, in the parish of Westerkirks, in the pastoral vale of Eskdale, a district in the county of Dumfries, in Scotland. His parents, although they occupied an humble station in the walks of life, were respected and beloved by all who knew them. The outset of the life of their son Thomas corresponded to their situation in society, and was strikingly humble and obscure in comparison with its close. He began the world as a working stone-mason in his native parish, and for a long time was only remarkable for the neatness with which he cut the letters upon those frail sepulchral memorials, which "teach the rustic moralist to die."

His occupation, fortunately, afforded a greater number of leisure hours than what are usually allowed by such laborious employments, and these young Telford turned to the utmost advantage in his power. Having previously acquired the elements of learning, he spent all his spare time in poring over such volumes as fell in his way, with no better light than was afforded by the cottage fire. Under these circumstances, his mind took a direction not uncommon among rustic youths: he became a noted rhymster in the homely style of Ramsay and Ferguson, and while still a very

young man, contributed verses to Ruddiman's Weekly Magazine, under the unpretending signature of "Eskdale Tam." In one of these compositions which was addressed to Burns, he sketched his own character, and his own ultimate fate :—

> Nor pass the tentie curious lad,
> Who o'er the ingle hangs his head,
> And begs of neighbors books to read ;
> For hence arise,
> Thy country's sons, who far are spread,
> Baith bold and wise.

Though Mr. Telford afterwards abandoned the thriftless trade of versifying, he is said to have retained through life a strong "frater feeling" for the corps, which he showed in a particular manner on the death of Burns, in exertions for the benefit of the family.

Having completed his apprenticeship as a stone mason, in his native place, he repaired to Edinburgh, where he found employment, and continued with unremitting application to study the principles of architecture agreeable to the rules of science. Here he remained three or four years, when having made a considerable proficiency, he left the Scottish capital, and went to London, under the patronage of Sir William Pulteney, and the family of Pasley, who were townsmen of Telford.

He now found himself in a scene which presented scope for his industry and talent. Fortunately, he did not long remain unnoticed, or unemployed. His progress was not rapid, but steady, and always advancing ; and every opportunity for displaying his taste, science, and genius, extended his fame, and paved the way to new enterprises and acquisitions. The first public employment in which he was engaged, was that of superintending some works belonging to government, in Portsmouth Dock Yard. The duties of this undertaking were discharged with so much fidelity and care, as to give complete satisfaction to the commissioners, and to ensure the future exercise of his talents and services. Hence, in 1787, he was appointed surveyor of public works in the rich and extensive county of Salop, which situation he retained until his decease.

A detail of the steps by which Mr. Telford subsequently placed himself at the head of his profession of engineering, would, most likely, only tire our readers. It is allowed on all hands, that his elevation was owing solely to his consummate ability and persevering industry, unless we are to allow a share in the process to the very strict integrity which marked his career. His works

are so numerous all over Great Britain, that there is hardly a county in England, Wales, or Scotland, in which they may not be pointed out.

Nor was the British empire alone benefited by Mr. Telford's genius. In the year 1808, he was employed by the Swedish government to survey the ground, and lay out an inland navigation through the central parts of that kingdom. The design of this undertaking was to connect the great fresh water lakes, and to form a direct communication by water, between the North Sea and the Baltic.

Mr. Telford's fame as an engineer has been principally spread in Great Britain by his great work, the Dublin road from London to Holyhead, including the Menai and Conway bridges. The Menai bridge, one of the greatest wonders of art in the world, is unquestionably the most imperishable monument of his capacity for extensive undertakings. This bridge is constructed over the small strait of the sea, which intervenes between the mainland of North Wales, and the island of Anglesea, and carries onward the road to Holyhead. Before its erection, the communication was carried on by means of ferry boats, and was therefore subject to delays and dangers. The bridge is at a point near the town of Bangor, from near which its appearance is strikingly grand. It is built partly of stone and partly of iron, on the suspension principle, and consists of seven stone arches, exceeding in magnitude every work of the kind in the world. They connect the land with the two main piers, which rise 53 feet above the level of the road, over the top of which the chains are suspended, each chain being 1714 feet from the fastenings in the rock. The first three-masted vessel passed under the bridge in 1826. Her topmasts were nearly as high as a frigate; but they cleared 12½ feet below the centre of the roadway. The suspending power of the chains was calculated at 2016 tons; the total weight of each chain, 121 tons.

This stupendous undertaking occasioned Mr. Telford more intense thought than any other of his works. He told a friend that his state of anxiety for a short time previous to the opening of the bridge was so extreme, that he had but little sound sleep, and that a much longer continuance of that condition of mind must have undermined his health. Not that he had any reason to doubt the strength and stability of every part of the structure, for he had employed all the precautions that he could imagine useful, as suggested by his own experience and consideration, or by the zeal and talents of his very able and faithful assistants; yet the bare possibility, that some weak point might have escaped his and their

MENAI SUSPENSION BRIDGE

vigilance in a work so new, kept the whole structure constantly in review before his mind's eye, to examine if he could discover a point that did not contribute its share to the perfection of the whole. In this, as in all his great works, he employed, as sub-engineers, men capable of appreciating and acting on his ideas; but he was no rigid stickler for his own plans, for he most readily acquiesced in the reasonable suggestions of his assistants, and thus identified them with the success of the work. In ascertaining the strength of the materials for the Menai bridge, he employed men of the highest rank for scientific character and attainments.

The genius of Telford, as has been stated, was not confined to his profession. Dr. Currie says, in his life of Burns, that a great number of manuscript poems were found among the papers of Burns, addressed to him by admirers of his genius, from different parts of Britain, as well as Ireland and America. Among these was a poetical epistle of superior merit, by Telford, and addressed to Burns, and in the versification generally employed by that poet himself. Its object is to recommend him to other subjects of a serious nature, similar to that of the Cottar's Saturday Night, and the reader will find that the advice is happily enforced by example. We extract a portion of it:—

"Pursue, O Burns, thy happy style,
'Those manner-painting strains,' that while
They bear me northward mony a mile,
Recall the days
When tender joys, with pleasing smile,
Blest my young ways.

I see my fond companions rise;
I join the happy village joys;
I see our green hills touch the skies,
And through the wood
I hear the river's rushing noise—
Its roaring flood.

No distant Swiss with warmer glow
E'er heard his native music flow,
Nor could his wishes stronger grow
Than still have mine,
When up this rural mount I go
With songs of thine.

O happy bard! thy generous flame
Was given to raise thy country's fame,
For this thy charming numbers came—
Thy matchless lays:
Then sing, and save her virtuous name
To latest days."

Mr. Telford was not more remarkable for his great professional abilities, than for his sterling worth in private life. His easiness of access, and the playfulness of his disposition, even to the close of life, endeared him to a numerous circle of friends, including all the most distinguished men of his time. He was the patron of merit in others, wherever it was to be found; and he was the means of raising many deserving individuals from obscurity to situations where their talents were seen, and soon appreciated. Up to the last period of his life, he was fond of young men, and of their company, provided they delighted in learning. His punctuality was universal.

In the course of his very active life, he found time to acquire a knowledge of the Latin, French, and German languages. He understood Algebra well, but thought it led too much to abstraction, and too little to practice. Mathematical investigation he also held rather cheaply, and always, when practicable, resorted to experiment to determine the relative value of any plans on which it was his business to decide. He delighted to employ the *vast* in nature, yet did not despise *minutiæ*, a point too seldom attended to by projectors.

For some years before his death, he gradually retired from professional employment, and he latterly amused his leisure hours by writing a detailed account of the principal undertakings which he had planned, and lived to see executed. The immediate cause of Mr. Telford's death was a repetition of severe bilious attacks, to which he had for some years been subject, and which, at length, proved fatal. His life, prolonged by temperance and cheerfulness, at length drew to a close, and he expired at his house, in Abingdon street, Westminster, September 2d, 1834.

EDMUND CARTWRIGHT,

THE INVENTOR OF THE POWER-LOOM.

Edmund Cartwright was born in the year 1743, and was the fourth son of William Cartwright, Esq. of Marnham, in Nottinghamshire. Being intended for the church, Edmund at the usual age was entered of University College, Oxford; from whence he was subsequently elected a Fellow of Magdalen College. He early distinguished himself by his literary attainments, an evidence of

which he gave to the world while yet a young man by the publication of a small volume of poems, which was very favorably received. About the year 1774, also, he became a contributor to the Monthly Review; for which he continued to write during the following ten years.

For the first forty years of his life he had never given any attention to the subject of mechanics; although, as was recollected long afterwards, his genius for invention in that department had once displayed itself, while at his father's house during one of his college vacations, in some improvements which he made on an agricultural machine which happened to attract his notice. But this exercise of his ingenuity, being out of the line of his pursuits at that time, led to no other attempts of the kind, nor to any farther application of his thoughts to such matters.

The circumstances which many years after this led him to the invention of his weaving machine, or power-loom, as it is commonly called, cannot be better described than they have been by himself in the following statement,—first printed in the Supplement to the Encyclopædia Britannica. "Happening," he says, "to be at Matlock in the summer of 1784, I fell in company with some gentlemen of Manchester, when the conversation turned on Arkwright's spinning machinery. One of the company observed that as soon as Arkwright's patent expired, so many mills would be erected, and so much cotton spun, that hands would never be found to weave it. To this observation I replied, that Arkwright must then set his wits to work to invent a weaving-mill. This brought on a conversation upon the subject, in which the Manchester gentlemen unanimously agreed that the thing was impracticable; and in defence of their opinion they adduced arguments which I was certainly incompetent to answer, or even to comprehend, being totally ignorant of the subject, having never at the time seen a person weave. I controverted, however, the impracticability of the thing by remarking that there had been lately exhibited in London an automaton figure which played at chess. Now you will not assert, gentlemen, said I, that it is more difficult to construct a machine that shall weave, than one that shall make all the variety of moves that are required in that complicated game. Some time afterwards a particular circumstance recalling this conversation to my mind, it struck me that, as in plain weaving, according to the conception I then had of the business, there could be only three movements, which were to follow each other in succession, there could be little difficulty in producing and repeating them. Full of these ideas, I immediately employed a carpenter and smith to carry them into effect. As soon as the machine was finished, I got a weaver to put

in the warp, which was of such materials as sail-cloth is usually made of. To my great delight, a piece of cloth, such as it was, was the produce. As I had never before turned my thoughts to mechanism, either in theory or practice, nor had seen a loom at work, nor knew any thing of its construction, you will readily suppose that my first loom must have been a most rude piece of machinery. The warp was laid perpendicularly, the reed fell with a force of at least half a hundred weight, and the springs which threw the shuttle were strong enough to have thrown a Congreve rocket. In short, it required the strength of two powerful men to work the machine, at a slow rate, and only for a short time. Conceiving in my simplicity that I had accomplished all that was required, I then secured what I thought a most valuable property by a patent, 4th of April, 1785. This being done, I then condescended to see how other people wove; and you will guess my astonishment when I compared their easy modes of operation with mine. Availing myself, however, of what I then saw, I made a loom in its general principles nearly as they are now made. But it was not till the year 1787, that I completed my invention, when I took out my last weaving patent, August the 1st of that year."

Dr. Cartwright's children still remember often seeing their father about this time walking to and fro apparently in deep meditation, and occasionally throwing his arms from side to side; on which they used to be told that he was thinking of weaving and throwing the shuttle. From the moment indeed when his attention was first turned to the invention of the power-loom, mechanical contrivance became the grand occupying subject of his thoughts. With that sanguineness of disposition which seems to be almost a necessary part of the character of an inventor, he looked upon difficulties, when he met with them in any of his attempts, as only affording his genius an occasion for a more distinguished triumph; nor did he allow even repeated failures for a moment to dishearten him. Some time after he had brought his first loom to perfection, a manufacturer, who had called upon him to see it at work, after expressing his admiration of the ingenuity displayed in it, remarked that, wonderful as was Mr. Cartwright's mechanical skill, there was one thing that would effectually baffle him,—the weaving, namely, of patterns in checks, or, in other words, the combining, in the same web, of a pattern, or fancy figure, with the crossing colors which constitute the check. Mr. Cartwright made no reply to this observation at the time; but some weeks after, on receiving a second visit from the same person, he had the pleasure of showing him a piece of muslin, of the description mentioned, beautifully executed by machinery. The man is said to have been so much

astonished, that he roundly declared his conviction that some agency more than human must have been called in to assist on the occasion.

The weaving factory which was erected at Doncaster, by some of Cartwright's friends, with his license, was unsuccessful; and another establishment containing five hundred looms, built at Manchester, was destroyed in 1790 by an exasperated mob. The invention had surmounted all opposition at the time of his death, and is stated then to have increased in use so rapidly as to perform the labor of *two hundred thousand men!*

Cartwright's next invention was to *comb wool by machinery*, which excited if possible a still greater ferment among the working classes than even the power-looms. The whole body of wool combers petitioned parliament to suppress the obnoxious machines, but without effect. These machines began to be used by some manufacturers, who at the same time attempted to evade Cartwright's claim as their inventor. After a trial which occupied twenty-six hours, he established his right, and gained a verdict of one thousand pounds against the pirates.

For several other inventions in agriculture and manufactures he took out patents, and for others premiums were bestowed upon him by the Society for the Encouragement of Arts, and the Board of Agriculture. Even the steam engine engaged his attention; and an account of some improvements which he proposed in its mechanism may be found in Reese's Cyclopedia. Indeed, so long as forty years ago, while residing at Eltham in Lincolnshire, he used frequently to tell his son that, if he lived to be a man, he would see both ships and land-carriages impelled by steam. It is also certain that at that early period he had constructed a model of a steam engine attached to a barge, which he explained about the year 1793, in the presence of his family, to Robert Fulton, then a student of painting under West. Even so late as the year 1822, Dr. Cartwright, notwithstanding his very advanced age, and although his attention was much occupied by other philosophical speculations, was actively engaged in endeavoring to contrive a plan of propelling land-carriages by steam.

His death, however, at Hastings, in October, 1823, prevented the completion of this, as well as of many other designs in the prosecution of which he had been employed. His enthusiasm for mechanical invention continued unabated to the last; and indeed his general energy both of mind and body was very little impaired up to within a short period of his death. In a letter to his brother, Major Cartwright, dated 24th April, 1819, he says, "I this day entered into my 77th year in as good health and spirits, thank

God, as I have done on any one birthday for the last half century I am moving about my farm from eight o'clock in the morning till four in the afternoon, without suffering the least fatigue. I sent in my claim to the Board of Agriculture for their premium for a cure of the mildew on wheat, but have not yet heard that it was admitted. I don't know whether I ever mentioned to you a machine for dibbling or planting wheat, which I have brought to great perfection. I have also a very material improvement on the stocks respecting ploughs and wheel-carriages; but of this I shall say nothing till I have brought it to the proof, which I hope to do very shortly; when you shall be immediately informed of the result, whether favorable or not." The following verses, also, which he sent to a friend not long before his death, will show at once the undiminished ardor and activity of his mind, and the generous and philanthropic motives by which his enthusiasm was sustained and directed:—

"Since even Newton owns that all he wrought
Was due to industry and patient thought,
What shall restrain the impulse which I feel
To forward, as I may, the public weal?
By his example fired, to break away,
In search of truth, through darkness into day?
He tried, on venturous wing, the loftiest flight,
An eagle soaring to the fount of light!
I cling to earth, to earth-born arts confined,
A worm of science of the humblest kind.
Our powers, though wide apart as earth and heaven,
For different purposes alike were given:
Though mine the arena of inglorious fame,
Where pride and folly would the strife disdain,
With mind unwearied still will I engage
In spite of failing vigor and of age,
Nor quit the combat till I quit the stage:
Or, if in idleness my life shall close,
Let well-earned victory justify repose!"

The disposition of this excellent man, indeed, naturally carried him throughout his life to promote, by every means in his power, the benefit of his fellow creatures; and the following incident is perhaps worthy of being recorded, as illustrating how this tendency used to display itself in other parts of his conduct, as well as in his zeal for mechanical improvements. While he held the living of Goadly Maxwood, in Leicestershire, he applied himself so assiduously to the study of medicine that he acquired extensive knowledge and eminent skill in that science, and was in the habit of prescribing to his poorer parishioners with great success.

Actuated by such feelings as those we have described, Dr. Cartwright was as free as any man who ever lived from jealousy or illiberality towards other inventors. In fact, it may be safely

asserted, that had he not carried his frankness and want of suspicion, as well as his indifference to pecuniary gains, beyond the limits of worldly prudence, his ingenious contrivances would in all probability have been productive of much greater benefit to himself than they ever actually were. So careless was he in regard to retaining in his own possession the valuable ideas with which his mind was continually teeming, that he has been frequently known to have given the most important assistance by his suggestions to other persons engaged like himself in mechanical pursuits, and afterwards to have forgotten the circumstance as entirely as if it had never happened. Nay, so completely did what he was engaged about at the moment occupy his mind, that he sometimes forgot his own inventions, and other productions, of an older date, even when his attention was particularly called to them. One day, one of his daughters having chanced to repeat in his presence some lines from a poem entitled the "Prince of Peace," which appeared in his volume already mentioned, he exclaimed, to her surprise and amusement, "Those are beautiful lines, child; where did you meet with them?" On another occasion, being shown the model of a machine, he examined it with great attention, and at last observed, that the inventor must have been a man of great ingenuity, and that he himself should feel very proud if he had been the author of the contrivance; nor could he be immediately convinced of what was proved to be the case, namely, that it was a machine of his own.

Dr. Cartwright was defrauded of the pecuniary profits which he might reasonably have expected from his great invention of the power-loom, by various accidents, and especially by the burning of a manufactory, containing five hundred of his machines, almost immediately after it was built. It may also be added, that after he had demonstrated the practicability of weaving by machinery other inventors applied themselves to the devising of contrivances for that purpose slightly different from his—a comparatively easy task, even where the new invention was not merely a disguised infringement of his patent, while in those cases in which it was in reality nothing more than such an infringement, it was yet so protected, that it could hardly be reached and put down as such. On these and other accounts, and in no small degree owing to Dr. Cartwright's carelessness about his own interests, the power-loom only began, in point of fact, to be extensively introduced about the year 1801, the very year in which his patent expired. So generally, however, was it felt among those best entitled to express an opinion on the subject, that to him really belonged the merit of the invention, that in the year 1808, several merchants and manufac-

turers of Manchester and its neighborhood, to none of whom he was personally known, held a meeting to consider the propriety of presenting to the Lords of the Treasury a memorial of his eminent services, and of the losses he had sustained through the piracies and other unfortunate circumstances to which we have alluded. In consequence of this and other applications in his favor, the sum of ten thousand pounds was soon after granted him by parliament. An amount, although munificent as a present, yet barely adequate even to repay the sums the doctor had expended in his experiments; and his family, after all, reaped no pecuniary benefit from his ingenious and persevering labors. This national recognition of his claims may be taken as a sufficient answer to some attempts that have been occasionally made to rob Dr. Cartwright of the credit of having been the author of one of the most valuable presents ever made to the manufacturing industry of his country.

As a man of education and literary habits, the inventor of the power-loom, notwithstanding his deviation from his original track of thought and study when he began to give his attention to mechanics, may yet be said to have come even to that new line of pursuit with certain acquired advantages. He brought with him at least a mind awakened to some knowledge of its own powers by the general cultivation it had received, and not undisciplined by its accustomed exercises to habits of speculation and inquiry

JOHN WHITEHURST.

This individual, whose philosophical and mechanical researches have met with such universal attention, was born in Congleton, in Cheshire, April 10, 1713: he was the son of a clock and watch maker of the same name in that town.

Of the early part of his life little is known. He who dies at a very advanced age leaves few behind him to communicate anecdotes of his youth. On his leaving school, where the education he received was certainly very defective, he was bred up by his father to his own trade; in which, as in other mechanical and scientific pursuits, he soon gave intimations of future eminence.

At about the age of twenty-one, his eagerness after new ideas carried him to Dublin, having heard of an ingenious piece of mechanism in that city, consisting of a clock with certain curious appendages, which he was extremely desirous of seeing, and no less

so than of conversing with the maker. On his arrival, however, he could neither procure a sight of the former, nor draw the least hint from the latter concerning it. Thus disappointed, he thought of an expedient to accomplish his design. He accordingly took up his residence in the house of the mechanic, paying the more liberally for his board, as he had hopes of thence more readily obtaining the indulgence so eagerly wished for. As happened, he was accommodated with a room directly over that in which the favorite piece was kept carefully locked. The so long wished for opportunity soon occurred; for the artist being one day employed in examining the machine, was suddenly called down stairs. Whitehurst, ever on the alert, softly slipped into the room, inspected the machine, and having comprehended its principles, escaped undiscovered to his own apartment. His curiosity thus gratified, he shortly bid the machinist farewell, and returned to his father in England.

About two years after his adventure in Ireland, he left the place of his nativity, and entered into business for himself at Derby. His reputation as a clock and watch maker soon became very extended, and his character as a citizen such that he was enrolled as burgess.

He was also consulted in almost all the undertakings in the country round, where the aid of superior skill in mechanics, pneumatics, and hydraulics was required. His dwelling became the resort of the ingenious and scientific from every quarter, and frequently to such a degree as to impede him in the regular prosecution of his pursuits.

In 1775, when the act for the regulation of gold coin was passed, he was unexpectedly appointed to the office of stamper. In 1778, he published his "Inquiry into the Original State and Formation of the Earth;" being a work of many years' labor, and one by which he obtained considerable reputation. He was chosen a member of the Royal Society, May 13, 1779. He was also a member of some other philosophical societies, which admitted him to their respective bodies without his previous knowledge. But so remote was he from every thing that might savor of ostentation, that this circumstance was only known to very few of his confidential friends. Previous to his admission, he had inserted several different papers in their philosophical transactions.

In the summer of 1783, he made a second visit to Ireland, with a view to examine the Giant's Causeway, and other northern parts of that island, which he found to be almost entirely composed of volcanic matter; an account and representations of which were inserted in the second edition of his "Inquiry." During this ex-

cursion he erected an engine for raising water from a well to the summit of a hill in a bleaching ground at Tullidoi, in the county of Tyrone. This engine was worked by a current of water, and for its utility and ingenuity was unequalled, perhaps, in any country.

In 1787 he published his "Attempt towards obtaining Invariable Measures of Length, Capacity, and Weight, from the Mensuration of Time."

Though for some years previous to his death Mr. Whitehurst felt himself declining, yet his ever active mind remitted not of its accustomed exertion. Even in his last illness, before being confined entirely to his chamber, he was proceeding at intervals to complete a Treatise on Chimneys, Ventilation, and Garden Stoves, including some other plans for promoting the health and comfort of society. He was sensible of his approaching dissolution; and on Monday, February 18, 1788, in the seventy-fifth year of his age, terminated his laborious and useful life. He died in the very house where had recently lived and died another celebrated self-taught genius, James Ferguson.

However respectable Mr. Whitehurst may have been in mechanics, he was of far higher account with his acquaintances and friends on the score of his moral qualities. To say nothing of the uprightness and punctuality of his dealings in all transactions relative to business; few men have been known to possess more benevolent affections than he, or, being possessed of such, to direct them more judiciously to their proper ends. He was a philanthropist in the truest sense of the word. Though well known to many of the great, to whose good graces flattery is generally the readiest path, it is to be recorded to his honor, that he never once stooped to that degrading mode of obtaining favor, which he regarded as the lowest vice of the lowest mind. He had, indeed, a settled abhorrence, not of flattery only, but of every other deviation from truth, at whose shrine he may be said to have been a constant worshipper. The truth of things he was daily, more or less, in the habit of investigating, and truth of action he exemplified in the whole tenor of a long and singularly useful life.

JAMES HARGREAVES,

THE INVENTOR OF THE SPINNING JENNY.

This individual was a weaver at Stand Hill, near Blackburn: though illiterate and humble, he must be regarded as one of the great inventors and improvers of the cotton manufacture. His principal invention, and one which showed high mechanical genius, was the spinning jenny;—a machine, as tradition affirms, which owed its title to a fair damsel by the name of Jane. The date of this invention was some years before Arkwright obtained the patent for his water frame; and differs so completely from that machine, that there can be no suspicion of its being other than a perfectly original invention.

It may be necessary to explain to some readers, that the cotton was formerly, and is still, reduced from the state of the fleecy roll called a carding, into the state of spun thread, by repeated, though similar operations; the first draws out the carding, and gives it a very slight twist, so as to make it into a loose thread, about the thickness of a candle-wick, in which state it is called a roving or slubbin; the subsequent processes draw out the roving much finer, and at length reduce it into yarn.

The jenny, like Arkwright's machine, was intended to spin the roving into yarn; but, unlike Arkwright's, was incapable of being applied to the preparation of the roving itself.

Hargreaves is said to have received the original idea of his machine from seeing a one-thread wheel overturned upon the floor, when both the wheel and spindle continued to revolve. The spindle was thus thrown from a horizontal into an upright position; and the thought seems to have struck him, that if a number of spindles were placed upright, and side by side, several threads might be spun at once. He contrived a frame, in one part of which he placed eight rovings in a row, and in another part a row of eight spindles. The rovings, when extended to the spindles, passed between two horizontal bars of wood forming a clasp, which opened and shut somewhat like a parallel ruler; when pressed together, this clasp held the threads fast. A certain portion of roving being extended from the spindles to the wooden clasp, the clasp was closed, and was then drawn along the horizontal frame to a considerable distance from the spindles, by which the threads were lengthened out, and reduced to the proper tenuity; this was done

with the spinner's left hand, and his right hand, at the same time, turned a wheel, which caused the spindles to revolve rapidly, and thus the roving was spun into yarn. By returning the clasp to its first situation, and letting down a presser wire, the yarn was wound upon the spindle.

With this admirable machine, though at first rudely constructed, Hargreaves and his family spun weft for his own weaving. Aware of the value of the invention, but not extending his ambition to a patent, he kept it as secret as possible for a time, and used it merely in his own business. A machine of such powers could not, however, be long concealed; but when it became the subject of rumor, instead of gaining for its author admiration and gratitude, the spinners raised an outcry that it would throw multitudes out of employment, and a mob broke into Hargreave's house, and destroyed his jenny. So great was the persecution he suffered, and the danger in which he was placed, that this victim of popular ignorance was compelled to flee, as the inventor of the fly-shuttle had before him. Thus the neighborhood where the machine was invented lost the benefit of it, yet without preventing its general adoption;—the common and appropriate punishment of the ignorance and selfishness which oppose mechanical improvements.

Hargreaves retired to Nottingham in 1768, where he entered into partnership with Mr. Thomas James, a joiner, who raised sufficient money to enable them to erect a small mill. He took out a patent for the jenny in 1770, the year after Arkwright had taken out his. The patent was "for a method of making a wheel or an engine of an entire new construction, and never before made use of, in order for spinning, drawing, and twisting of cotton, and to be managed by one person only; and that the wheel or engine will spin, draw, and twist *sixteen* or more threads at one time, by a turn or motion of one hand and a draw of the other."

The following is the inventor's description of the process:—"One person, with his or her right hand, turns the wheel, and with the left hand takes hold of the clasps, and therewith draws out the cotton from the slubbin box; and being twisted by the turn of the wheel in the drawing out, then a piece of wood is lifted by the toe, which lets down a presser wire, so as to press the threads so drawn out and twisted, in order to wind or put the same regularly upon bobbins which are placed on the spindles." The number of spindles in the jenny was at first eight; when the patent was obtained it was sixteen; it soon came to be twenty or thirty; and no less than one hundred and twenty have since been used.

Before quitting Lancashire, Hargreaves had made a few jennies for sale; and the importance of the invention being universally

appreciated, the interests of the manufacturers and weavers brought it into general use, in spite of all opposition. A desperate effort, though, was made in 1779—probably in a period of temporary distress—to put down the machine. A mob rose and scoured the country for several miles around Blackburn, demolishing the jennies, and with them all the carding engines, water frames, and every machine turned by water or horses. It is said the rioters spared the jennies which had only twenty spindles, as these were by this time admitted to be useful, but those with a greater number, being considered mischievous, were destroyed, or cut down to the prescribed dimensions.

It may seem strange that not merely the working classes, but even the middle and higher ranks of people, entertained a great dread of machinery. Not perceiving the tendency of any invention which improved and cheapened the manufacture, to cause an extended demand for its products, and thereby to give employment to more hands than it superseded, those classes were alarmed lest the poor rates should be burdened with workmen thrown idle. They therefore connived at, and even actually joined in the opposition to the machinery, and did all in their power to screen the rioters from punishment.

This devastating outrage left effects more permanent than have usually resulted from such commotions. Spinners and other capitalists were driven from the neighborhood of Blackburn to Manchester and other places, and in consequence it was many years before cotton spinning was resumed at Blackburn.

Hargreaves went to Nottingham in 1768, and worked for a while in the employment of Mr. Shipley, for whom he secretly made some jennies in his dwelling. He was induced, by the offers of Mr. Thomas James, to enter into partnership with him; and the latter raised sufficient money, on mortgage and loan, to build a small mill in Hockley, where they spun yarn for the hosiers with the jenny. The patent was obtained in 1770.

Finding that several of the Lancashire manufacturers were using the jenny, Hargreaves gave notice of actions against them; the manufacturers met, and sent a delegate to Nottingham, who offered Hargreaves three thousand pounds for permission to use the machine; but he at first demanded seven thousand, and at last stood out for four thousand. The negotiation being broken off, the actions proceeded; but before they came to trial, Hargreaves' attorney was informed that his client, before leaving Lancashire, had sold some jennies to obtain clothing for his children, of whom he had six or seven. In consequence, the attorney gave up the actions, in despair of obtaining a verdict.

The spinning business was carried on by the partners with moderate success, till the death of Mr. Hargreaves, which took place at his own house, near the mill, in April, 1778. In his will he directed a guinea to be given to the vicar for preaching his funeral sermon. His widow received four hundred pounds from Mr. James, for her husband's share in the business.

It is a consolation to the admirers of genius to know, that this benefactor to his country was enabled to live in comfort, though not in affluence, on the fruits of his invention.

JOSEPH BRAMAH,

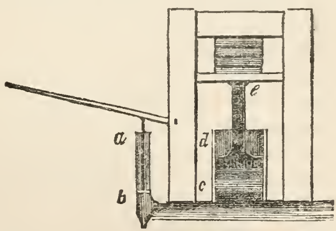
THE INVENTOR OF THE HYDROSTATIC PRESS.

Joseph Bramah, one of the greatest mechanics England has ever produced, was the oldest son of a small farmer, and was born on the 13th of April, 1749, at Stainsborough, in Yorkshire. He exhibited at a very early age an unusual talent for mechanical contrivances, and succeeded, when quite a boy, in making two violoncellos, which were found to be very tolerable instruments. His hours of relaxation from the business of the farm were generally spent in a neighboring blacksmith-shop, between whose tenant and himself was shared the merit of several ingenious pieces of mechanism.

An accidental lameness in his ankles unfitting him for agricultural labor, he was apprenticed in his sixteenth year to a carpenter and joiner. At the expiration of his "time," he went to London in search of employment, where, by his industry and exertions, he soon became a master. His now extended means enabled him to indulge his mechanical taste, and he quickly became known as a man possessing a fine invention as well as great executive skill. In 1784, he produced the admirable lock which bears his name, and which was considered the most perfect mechanism of its kind that had ever been produced, and even to this day is scarcely rivalled for safety, durability, elegance, and simplicity. The peculiar character of this lock depends on the arrangement of a number of levers, or sliders, to preserve, when at rest, a uniform situation, and to be only pressed down by the key to a certain depth, which nothing but the key can ascertain,—the levers not having any stop to retain them in their required situation, except

that which forms part of the key. He added afterwards some modifications, for allowing the key to be varied at pleasure. The report that one of these locks had been readily opened before a committee of the House of Commons, by means of a common quill, was a gross misrepresentation of the fact; the quill having, in reality, been previously cut into the required shape from the true key. An experiment which was only made to show the perfection of the workmanship, and the very small force requisite to overcome the resistance when properly applied. It has been stated that one of these locks, after having been in use many years, and opened and locked not less than four hundred thousand times, was apparently as perfect as when first constructed. The invention for which he will probably be best known to posterity, is his hydrostatic press, which is described in the succeeding paragraph:—

The principle of this machine is this: if a given pressure, as that given by a plug forced inwards upon a square inch of the surface of a fluid confined in a vessel, is suddenly communicated to every square inch of the vessel's surface, however large, and to every inch of the surface of any body immersed in it,—thus if we attempt to force a cork into a vessel full of water,—the pressure will not merely be felt by the portion of the water directly in the range of the cork, but by all parts of the mass alike; and the liability of the bottle to break, supposing it to be of uniform strength throughout, will be as great in one place as another. And a bottle will break at the point wherever it is the weakest, however that point may be situated relatively to the place where the cork is applied; and the effect will be the same whether the stopper be inserted at the top, bottom, or side of the vessel. It is this power which operates with such astonishing effect in the Hydrostatic Press. The annexed engraving represents a press made of the strongest timbers, the foundation of which is com-



monly laid in solid masonry. A B is a small cylinder, in which moves the piston of a forcing pump, and C D is a large cylinder,

in which also moves a piston, having the upper end of its rod pressing against a moveable plank E, between which and the large beam above is placed the substance to be subjected to pressure, as, for example, a pile of new-bound books. By the action of the pump handle, water is raised into the small cylinder, and on depressing the piston, it is forced through a valve at B into the large cylinder, and raises the piston D, which expends its whole force on the bodies confined at E. Now, since whatever force is applied to any one portion of the fluid extends alike to every part, therefore the force which is exerted by the pump upon the smaller column, is transmitted unimpaired to every inch of the larger column, and tends to raise the moveable plank, E, with a force as much greater, in the aggregate, than that impressed upon the surface of the smaller, as this surface is smaller than that of the larger column; or (which is the same thing) as the number of square inches in the end of the piston B is less than that of the piston D. The power of such a machine is enormously great; for supposing the hand to be applied at the end of the handle with a force of only ten pounds, and that this handle or lever is so constructed as to multiply that force but five times, the force with which the smaller piston will descend will be equal to fifty pounds; and let us suppose that the head of the larger piston contains the smaller fifty times, then the force exerted to raise the press board will equal two thousand five hundred pounds. A man can indeed easily exert ten times the force supposed, and can therefore exert a force upon the substance under pressure equal to twenty-five thousand pounds!

Here, too, the mere application of the puny force of a child's arm is sufficient to tear up trees by the roots, and crush bars of iron as though they were pieces of wax. If as an invention for developing power it is equal in importance to the steam engine, but unlike it, its use is not limited by any circumstances of a local nature, for it does not depend on a consumption of any extraneous substance whatever; two small pipes, each fitted with a piston and a little water, which for years needs no replenishing, gives to an ordinary man in all situations the strength of a giant.

This machine, one of the most admirable in the whole compass of the arts, has been called, by some envious blockheads, "Pascal's Machine;" and, in their descriptions, they almost say Pascal invented it; but that ingenious philosopher has about as much claim to this great honor, as the old woman who first discovered her beard and her wrinkles in her polished pewter platter, had to be considered as the inventress of the Newtonian telescope! Before Bramah's time, Bonifaces were obliged to trudge to the

cellar for every drop of the beverage they measured out to their customers, or have their barrels placed in waiting on the same level with their parlor. In most states of the weather this was a hazardous position, and in some atmospheres very injurious; but Bramah, by his elegant "Beer Machine," enabled them to pump up into the measure, in the bar, the fermented juice contained in the various casks in the cellar.

Machinery for smoothing surfaces was another of his elaborate and beautiful specimens of mechanism. It was erected at the Woolwich Arsenal with perfect success: the axis of the principal shaft was supported on a piston in a vessel of oil, which diminished the friction considerably, and could be accurately measured by means of a small forcing pump. He introduced also a mode of turning spherical surfaces either convex or concave, by a tool moveable on an axis perpendicular to that of the lathe; and fixing a curved tool in the same position, he cut out concentric sheets. He also described machinery for making paper in large sheets, for printing by means of a roller, composed of a number of circular plates, turning on the same axis, each bearing twenty-six letters capable of being shifted at pleasure, so as to express any single line by a proper combination of the plates. This was put in practice to number bank notes, and enable the clerks to do six where before they could only number one.

In 1812, he produced his project for main pipes, which in some parts was more ingenious than practicable. In describing them, he mentions having employed an hydrostatic pressure equal to that of a column of water twenty thousand feet high, (about four tons for every inch.) He also asserts that he can form five hundred tubes, each five feet long, capable of sliding within each other, and of being extended in a few seconds, by the pressure of air forced into them, to a length of two thousand five hundred feet; with this power he proposed to raise wrecks, and regulate the descent of weights. His improvements in wheel carriages consisted in fixing each wheel to a separate moveable axis, having its bearings at two distinct points of its length, but loosely enclosed between those points in a cylinder filled with oil; in another, opposite wheels were to be fixed on the same axis, though with the power of turning very stiffly round it to lessen the lateral motion on rough roads; and he suggests pneumatic springs, formed by pistons sliding in cylinders, as a substitute for springs of metal: latterly he improved the machines for sawing stones and timber, and suggested some alterations in the construction of bridges and canal locks. His last illness was occasioned by a severe cold,

taken during some experiments in tearing up of trees in a forest He died on the 9th of December, 1814.

Bramah was a sincere and unostentatious follower of the precepts of Christianity: his conversation was animated, and to much facility of expression he added the most perfect independence of opinion: he was a cheerful, benevolent, and affectionate man—neat and methodical in his habits—and knew well how to temper liberality with economy. Greatly to his honor, he often kept his workmen employed, solely for their sake, when the stagnation of trade prevented him disposing of the products of their labor. As a manufacturer, he was distinguished for his promptitude and integrity, and celebrated for the exquisite finish which he gave to his productions

ANECDOTES, DESCRIPTIONS,

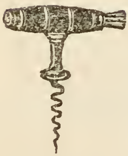
ETC., ETC ,

RELATING TO THE MECHANIC ARTS.

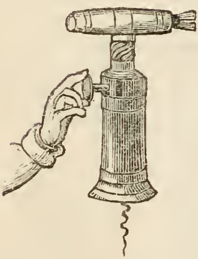
Progress of Invention illustrated.

The progressive stages through which even some of our *simplest* tools have to pass, ere they arrive at their final state of perfection, is sometimes astonishing. The simple process of drawing a cork will furnish the necessary illustrations.

The inventor of bottles is unknown; but these were in use centuries before corks were thought of, and these, again, were employed for generations before a convenient method was hit upon for their extraction. The exhilarating contents could then only be tasted by what was technically called "beheading the bottle." More expert practitioners had many opportunities of showing their skill in removing the impediment by a dexterous twist of the fingers; or, if that were impracticable, teeth were called in as their natural auxiliaries: here, however, in many cases, it was doubtful whether the cork would follow the teeth, or the teeth remain *in* the cork; and if an obstinate remnant would remain, a *nail* was a ready means of dislodging the stubborn plug, particle by particle. When at any time, through an impatience of the nibbling labor, or a despair of accomplishing a clean extraction at all, it was resolved to send the obstacle the wrong way; this was then, indeed, an invaluable instrument. A pair



of skewers, or forks, inserted "witchwise," would sometimes accomplish those difficult cases which had baffled the exertions of all the naturals. Twisting the lower extremity of the "bare bodkin" into a spiral form, and adding a handle to it, was the thought of a *master genius;* and in this shape mankind for ages were contented to avail themselves of its services; and even at the present hour, some barbarous, uncouth countries and districts may be named where it is still the extractor in most general use. In our country, it must be in the recollection of many, that this was in numerous cases a very inefficient machine; and no one hostess ever before conferred such a favor upon all bottle suckers as that lady who first conceived the idea of placing a *button* at the end of the screw-worm. Henceforth the decanting process was a mere matter of routine. When, in her green old age, death laid his hand on the inventress, a piratical screw-maker also took to himself the credit and profit of the button. Yet the fair originator shall be ne'er forgotten, even although her master-piece, some years later, was eclipsed, and may yet be superseded by the *King's screw,* which can receive no addition to its beauty or convenience.



Another illustration can be found in the *shoemaker's awl,* which is a much simpler instrument, even than the cork-screw. The first awls were *plain, conical punches,* that made a round hole in the leather. It was soon discovered that this form was erroneous, for the hole thus made was never more than half filled with the two waxed threads crossing each other. Geometry teaches us that these two threads, being like two small circles enclosed by a third, occupied but one half of the space of the hole.

The conical awl was then *flattened,* and had an oval form as to its section given to it; and some time afterwards the awl was so filed as to give it *four faces,* the section being something in the shape of a lozenge; but still the awl was straight. Although this straightness is useful in many cases, yet it was improper in the business of shoemaking. Suppose it were wished to sew together.

quite close to the edge, two pieces of leather, one placed upon the other, and that a straight awl is used; the hole that it will make will constantly push out the leather towards the edge and give it a convex form, and when the sewing is done the edge will exhibit a row of festoons, which it will be necessary to rub down by means of a knife, in order to give a regular edge to the pieces, but which, by this means, will lose much of its strength. Now, if, on the contrary, a crooked awl is used, and pushed in properly, it may be brought very near the edge, by making it describe the arc of a circle, whose convexity is opposite to the edge. By this simple means the festooned appearance of the edge produced by the straight awl will not be formed, and of course the strength of the leather will be preserved undiminished, and the sewing itself will be strong. Unfortunately, the name of the person who conceived the idea of *bending the awl* is lost.

Illustration of the Ignorance of Foreigners respecting American Inventions.

The ignorance of foreigners in relation to our country and its improvements in the mechanic arts, is well illustrated in the following conversation related by Allen, in his Travels, as having passed between himself and a Flemish gentleman, in a stage coach in Holland. In speaking of steam, he says:

"Our artisan was also eloquent in his eulogium upon steam navigation, having for the first time in his life made the passage from Rotterdam to Antwerp in the steam-packet. In a few years, he observed, steamboats would be in use in all parts of the country, and even in the United States of America we might not be long without them. His surprise was great, when informed that steamboats were in general use on most of the large rivers of the Union, where they were first successfully put into operation, some twenty years ago.

"The subject of mechanical inventions having been thus introduced, I described to him several of the curiously constructed machines invented by Americans. He continued to listen to an account of the nail machine, which cuts and heads nails from a flat bar of iron as fast as a man can count them. The machine for making weavers' reeds or slaies seemed to strike attention as a wonderful invention, whereby the mechanism is made to draw in the flattened wire from a reel, to insert it between the side pieces, to cut it off at the proper length, and finally, to bind each dent firmly in its place with tarred twine, accomplishing the whole operation

without the assistance of an attendant, in a more perfect manner than can be performed by the most skilful hand. He had never before heard of these machines: although possessed of a good share of intelligence, yet the complicated operations of the mechanism for accomplishing processes which he supposed could only be brought about by manual dexterity, appeared to him almost incredible. But when I described to him *Blanchard's Lathe*, in which gun-stocks and shoe-lasts, with all their irregularity of outline, are turned exactly to a pattern, his confidence in my veracity seemed evidently wavering, and on giving him a description of *Whittemore's celebrated card machine*, which draws off the wire from the reel,—cuts it into pieces of the proper length for teeth,—bends it into the form of a staple,—punctures the holes in the leather with a needle,—inserts the staples into these punctured holes in the leather,—and finally, crooks the teeth into the required form, completing of itself all those operations with regularity without the assistance of a human hand to direct it, the credulity of my travelling companion would extend no farther. He manifested doubts of all that I had been describing to him, accompanied by feelings of irritation at what he appeared to consider an attempt to impose upon him marvellous travellers' stories.

"Giving vent to an emphatic *humph!*—he petulantly threw himself back into the corner of the diligence, and would hold no farther conversation during the remainder of our ride, on the subject of mechanical improvements made in Flemish manufactures."

Singular Origin of the Invention of Frame-work Knitting.

The stocking frame, to any one who attentively considers its complex operations, and the elegant sleight with which it forms its successive rows of loops or stitches, will appear to be the most extraordinary single feat, the most remarkable stride, ever made in mechanical invention.

In the Stocking Weavers' Hall, in Red Cross street London, there is a portrait of a man, painted in the act of pointing to an iron stocking frame, and addressing a woman, who is knitting with needles by hand. The picture bears the following quaint inscription:—"In the year 1589, the ingenious William Lee, A. M., of St. John's College, Cambridge, devised this profitable art for stockings, (but being despised went to France,) yet of iron to himself, but to us, and to others, of gold; in memory of whom this is here painted."

This machine was constructed somewhere about the year 1600.

It was only about thirty years prior to its construction, that the art of knitting stockings, by wires worked by the fingers, had been introduced into England from Spain.

This Mr. Lee, it is said, paid his addresses to a young woman in his neighborhood, to whom, from some cause, his attentions were not agreeable; or, as with more probability it has been conjectured, she affected to treat him with negligence to ascertain her power over his affections. Whenever he paid his visits she always took care to be busily employed in knitting, and would pay no attention to his addresses; this conduct she pursued for so long a period, that the lover became disgusted, and he vowed to devote his leisure, instead of dancing attendance on a capricious woman, who treated his attention with cold neglect, in devising an invention that would effectually supersede her favorite employment of knitting. So sedulous was Mr. Lee in his new occupation, that he neglected every thing to accomplish this new object of his attentions; even his sacerdotal duties were neglected. In vain did his sweetheart endeavor to reclaim him; she found too late that she had carried her humor to far. All interests, all avocations, all affections were absorbed in his new pursuit, from which he imagined he should realize an immense fortune. His curacy was abandoned as beneath the notice of a person who had formed in his imagination such gigantic prospects.

The old stocking makers were fond of dilating in their cups and in their conversation on the difficulties he encountered. He watched his mistress with the greatest attention while knitting, and he observed that she made the web loop by loop, but the round shape which she gave to the stocking from the four needles, greatly embarrassed him in his notions of destroying her trade. Pondering in his mind the difficulties of his task, on one of his visits he found her knitting the heel of a stocking, and using only two needles; one was employed in holding the loops, while another was engaged in forming a new series. The thought struck him instantly that he could make a flat web, and then by joining the selvages with the needle, make it round. At the end of three years' excessive study and toil, Mr. Lee was enabled to make a course upon a frame; but here new difficulties presented themselves; he wrought with great facility the top, the narrowings, and the small of the leg, but the formation of the heel and foot embarrassed the ingenious mechanic, who had surmounted such seeming insuperable difficulties. After having to unreave a great number of abortive attempts, perseverance at length crowned his efforts, the clergyman attained the height of his wishes, and became the first *frame-work knitter*.

He brought the machine to such perfection that even to the pre-

sent time it has received no essential improvements. Having taught its use to his brother and the rest of his relations, he established his frame at Culverton, near Nottingham, as a formidable competitor of female handiwork, teaching his mistress, by the insignificance to which he reduced the implements of her pride, that the love of a man of genius was not to be slighted with impunity.

After practising this business for five years, he became aware of its importance in a national point of view, and brought his invention to London, to seek protection and encouragement from the court, by whom his fabrics were much admired. The period of his visit was not propitious. Elizabeth, the patroness of whatever ministered to her vanity as a woman, and her state as a princess, was in the last stage of her decline. Her successor was too deeply engrossed with political intrigues for securing the stability of his throne, to be able to afford any leisure to cherish an infant manufacture. Nay, though Lee and his brother made a pair of stockings in the presence of the king, it is said he viewed their frame rather as a dangerous innovation, likely to deprive the poor of labor and bread, rather than as a means of multiplying the resources of national industry and giving employment to many thousand people.

The encouragement which the narrow-minded James refused was offered by the French king Henry IV., and his sagacious minister Sully. They invited Lee to come to France with his admirable machines. Thither he accordingly repaired, and settled at Rouen, and gave an impulse to manufactures, which is even felt to the present day in that department. After Henry had fallen a victim to domestic treachery, Lee, envied by the natives whose genius he had eclipsed, was proscribed as a protestant, and obliged to seek concealment from the bloody bigots in Paris, where he ended his days in secret grief and disappointment. Some of his workmen made their escape into England, where, under his ingenious apprentice Aston, they mounted the stocking frame, and thus restored to its native country an invention which had well nigh been lost to it.

Ancient and Modern Labor.

The great Pyramid of Egypt cost the labor of one hundred thousand men for twenty years, exclusive of those who prepared and collected the materials. The steam engines of England, alone, worked by thirty-six thousand men, would raise the same quantity of materials to the same height in eighteen hours, which reckoning ten hours to the day, and three hundred working days to the year, would enable the moderns to erect over 3,000 pyramids in the same time

The Slide of Alpnach.

Amongst the forests which flank many of the lofty mountains of Switzerland, some of the finest timber is found in positions almost inaccessible. The expense of roads, even if it were possible to make them in such situations, would prevent the inhabitants from deriving any advantages from these almost inexhaustible supplies. Placed by nature at a considerable elevation above the spot on which they are required, they are precisely in fit circumstances for the application of machinery; and the inhabitants constantly avail themselves of it, to enable the force of gravity to relieve them from some portion of their labor. The inclined planes which they have established in various forests, by which the timber has been sent down to the water-courses, must have excited the admiration of every traveller; and these slides, in addition to the merit of simplicity, have that of economy, as their construction requires scarcely any thing beyond the material which grows upon the spot. Of all these specimens of carpentry, the Slide of Alpnach was by far the most considerable, both from its great length, and from the almost inaccessible position from which it descended. The following is the description of that work given in Gilbert's Annalen, 1819, and translated in the second volume of Brewster's Journal:—

For many centuries, the rugged flanks and the deep gorges of Mount Pilatus were covered with impenetrable forests. Lofty precipices encircled them on all sides. Even the daring hunters were scarcely able to reach them; and the inhabitants of the valley had never conceived the idea of disturbing them with the axe. These immense forests were therefore permitted to grow and to perish, without being of the least utility to man, till a foreigner, conducted into their wild recesses in the pursuit of the chamois, was struck with wonder at the sight, and directed the attention of several Swiss gentlemen to the extent and superiority of the timber. The most intelligent and skilful individuals, however, considered it quite impracticable to avail themselves of such inaccessible stores. It was not till November, 1816, that M. Rupp, and three Swiss gentlemen, entertaining more sanguine hopes, drew up a plan of a slide, founded on trigonometrical measurements. Having purchased a certain extent of the forests from the commune of Alpnach for six thousand crowns, they began the construction of the slide, and completed it in the spring of 1818.

The Slide of Alpnach is formed entirely of about 25,000 large pine trees, deprived of their bark, and united together in a very ingenious manner, without the aid of iron. It occupied about one

hundred and sixty workmen during eighteen months, and cost nearly one hundred thousand francs, or £4250. It is about three leagues, or forty-four thousand English feet long, and terminates in the Lake of Lucerne. It has the form of a trough, about six feet broad, and from three to six feet deep. Its bottom is formed of three trees, the middle one of which has a groove cut out in the direction of its length, for receiving small rills of water, which are conducted into it from various places, for the purpose of diminishing the friction. The whole of the slide is sustained by about two thousand supports; and in many places it is attached, in a very ingenious manner, to the rugged precipices of granite.

The direction of the slide is sometimes straight, and sometimes zig-zag, with an inclination of from 10° to 18°. It is often carried along the sides of hills, and the flanks of precipitous rocks, and sometimes passes over their summits. Occasionally it goes under ground, and at other times it is conducted over the deep gorges by scaffoldings one hundred and twenty feet in height.

The boldness which characterizes this work, the sagacity displayed in all its arrangements, and the skill of the engineer, have excited the wonder of all who have seen it. Before any step could be taken in its erection, it was necessary to cut several thousand trees, to obtain a passage through the impenetrable thickets; and, as the workmen advanced, men were posted at certain distances, in order to point out the road for their return, and to discover, in the gorges, the places where the piles of wood had been established. M. Rupp was himself obliged, more than once, to be suspended by cords, in order to descend precipices many hundred feet high; and, in the first months of the undertaking, he was attacked with a violent fever, which deprived him of the power of superintending his workmen. Nothing, however, could diminish his invincible perseverance. He was carried every day to the mountain in a barrow, to direct the labors of the workmen, which was absolutely necessary, as he had scarcely two good carpenters among them all; the rest having been hired by accident, without any of the knowledge which such an undertaking required. M. Rupp had also to contend against the prejudices of the peasantry. He was supposed to have communion with the devil. He was charged with heresy, and every obstacle was thrown in the way of an enterprise which they regarded as absurd and impracticable.

All these difficulties, however, were surmounted, and he had at last the satisfaction of observing the trees descend from the mountain with the rapidity of lightning. The larger pines, which were about a hundred feet long, and ten inches thick at their smaller extremity, ran through the space of *three leagues*, or nearly ***nine miles***

in two minutes and a half, and during their descent, they appeared to be only a few feet in length. The arrangements for this part of the operation were extremely simple. From the lower end of the slide to the upper end, where the trees were introduced, workmen were posted at regular distances, and as soon as every thing was ready, the workman at the lower end of the slide cried out to the one above him, '*Lachez*,' (let go.) The cry was repeated from one to another, and reached the top of the slide in *three minutes*. The workman at the top of the slide then cried out to the one below him, '*Il vient*,' (it comes,) and the tree was instantly launched down the slide, preceded by the cry which was repeated from post to post. As soon as the tree had reached the bottom, and plunged into the lake, the cry of *Lachez* was repeated as before, and a new tree was launched in a similar manner. By these means a tree descended every five or six minutes, provided no accident happened to the slide, which sometimes took place, but which was instantly repaired when it did.

In order to show the enormous force which the trees acquired from the great velocity of their descent, M. Rupp made arrangements for causing some of the trees to spring from the slide. They penetrated by their thickest extremities no less than from eighteen to twenty-four feet into the earth; and one of the trees having by accident struck against the other, it instantly cleft it through its whole length, as if it had been struck by lightning.

After the trees had descended the slide, they were collected into rafts upon the lake, and conducted to Lucerne. From thence they descended the Reuss, then the Aar to near Brugg, afterwards to Waldshut by the Rhine, then to Basle, and even to the sea when it was necessary.

In order that none of the small wood might be lost, M. Rupp established in the forest large manufactories of charcoal. He erected magazines for preserving it when manufactured, and had made arrangements for the construction of barrels, for the purpose of carrying it to the market. In winter, when the slide was covered with snow, the barrels were made to descend on a kind of sledge. The wood which was not fit for being carbonized, was heaped up and burnt, and the ashes packed up and carried away, during the winter.

A few days before the author of the preceding account visited the slide, an inspector of the navy had come for the purpose of examining the quality of the timber. He declared that he had never seen any timber that was so strong, so fine, and of such a size; and he concluded an advantageous bargain for one thousand trees.

Such is a brief account of a work undertaken and executed by

a single individual, and which has excited a very high degree of interest in every part of Europe. We regret to add, that this magnificent structure no longer exists, and that scarcely a trace of it is to be seen upon the flanks of Mount Pilatus. Political circumstances having taken away the principal source of the demand for timber, and no other market having been found, the operation of cutting and transporting the trees necessarily ceased.

Professor Playfair, who visited this singular slide, states, that six minutes was the usual time occupied in the descent of a tree, but that in wet weather it reached the lake in three minutes.

American Road-making.

"Road-making* is a branch of engineering which has been very little cultivated in America; and it was not until the introduction of railways that the Americans entertained the idea of transporting heavy goods by any other means than those afforded by canals and slackwater navigation. Their objection to paved or Macadamized roads such as are used in Europe, is founded on the prejudicial effects exerted upon works of that description by the severe and protracted winters by which the country is visited, and also the difficulty and expense of obtaining materials suitable for their construction, and for keeping them in a state of proper repair. Stone fitted for the purposes of road-making is by no means plentiful in America; and as the number of workmen is small in proportion to the quantity of work which is generally going forward in the country, manual labor is very expensive. Under these circumstances, it is evident that roads would have been a very costly means of communication, and as they are not suitable for the transport of heavy goods, the Americans, in commencing their internal improvements, directed their whole attention to the construction of canals, as being much better adapted to supply their wants.

"The roads throughout the United States and Canada are, from these causes, not very numerous, and most of those by which I travelled were in so neglected and wretched a condition as hardly to deserve the name of highways, being quite unfit for any vehicle but an American stage, and any pilot but an American driver. In many parts of the country, the operation of cutting a track through the forests of a sufficient width to allow vehicles to pass each other, is all that has been done towards the formation of a road. The

* Stevenson's Engineering in North America

roots of the felled trees are often not removed; and in marshes, where the ground is wet and soft, the trees themselves are cut in lengths of about ten or twelve feet, and laid close to each other across the road, to prevent vehicles from sinking, forming what is called in America a '*Corduroy road*,' over which the coach advances by a series of leaps and starts, particularly trying to those accustomed to the comforts of European travelling.

"On the road leading from Pittsburg on the Ohio to the town of Erie on the lake of that name, I saw all the varieties of forest road-making in great perfection. Sometimes our way lay for miles through extensive marshes, which we crossed by corduroy roads; at others the coach stuck fast in mud, from which it could be extricated only by the combined efforts of the coachman and passengers; and at one place we travelled for upwards of a quarter of a mile through a forest flooded with water, which stood to the height of several feet on many of the trees, and occasionally covered the naves of the coach-wheels. The distance of the route from Pittsburg to Erie is 128 miles, which was accomplished in forty-six hours, being at the very slow rate of about two miles and three quarters an hour, although the conveyance by which I travelled carried the mail, and stopped only for breakfast, dinner, and tea, but there was considerable delay caused by the coach being once upset and several times 'mired.'

"The best roads in the United States are those of New England, where, in the year 1796, the first American turnpike act was granted. These roads are made of gravel; a material which, by the way, is much used for road-making in Ireland. The surface of the New England roads is very smooth; but as no attention has been paid to forming or draining them, it is only for a few months during summer that they possess any superiority, or are, in fact, at all tolerable. In Virginia and all the states lying to the south, as well as throughout the whole country to the westward of the Alleghany mountains, the roads, I believe, are, generally speaking, of the same description as the one already mentioned between Pittsburg and Erie, affording very little comfort or facility to those who have the misfortune to be obliged to travel upon them.

"But on the construction of one or two lines of road, the Americans have bestowed a little more attention. The most remarkable of them is that called the 'National Road,' stretching across the country from Baltimore to the state of Illinois, a distance of no less than seven hundred miles, an arduous and extensive work, which was constructed at the expense of the government of the United States. The narrow tract of land from which it was necessary to remove the timber and brushwood for the passage of the road,

measures eighty feet in breadth; but the breadth of the road itself is only thirty feet. The line of the 'National Road' commences at Baltimore, passes through part of the state of Maryland, and entering that of Pennsylvania, crosses the range of the Alleghany mountains, after which it passes through the states of Virginia, Ohio, and Indiana, to Illinois. It is in contemplation to produce this line of road to the Mississippi at St. Louis, where, the river being crossed by a ferry-boat stationed at that place, the road is ultimately to be extended into the state of Missouri, which lies to the west of the Mississippi.

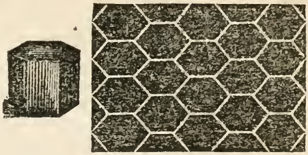
"The 'Macadamized road,' as it is called, leading from Albany to Troy, is another line which has been formed at some cost, and with some degree of care. This road, as its name implies, is constructed with stone broken, according to Macadam's principle. It is six miles in length, and has been formed of a sufficient breadth to allow three carriages to stand abreast on it at once. It belongs to an incorporated company, who are said to have expended about £20,000 in constructing and upholding it.

"Some interesting experiments have lately been set on foot at New York, for the purpose of obtaining a permanent and durable city road, for streets over which there is a great thoroughfare. The place chosen for the trial was the Broadway, in which the traffic is constant and extensive.

"The specimen of road-making first put to the test was a species of causewaying or pitching; but the materials employed are round water-worn stones, of small size; and their only recommendation for such a work appears to be their great abundance in the neighborhood of the town. The most of the streets in New York, and indeed in all the American towns, are paved with stones of this description; but, owing to their small size and round form, they easily yield to the pressure of carriages passing over them, and produce the large ruts and holes for which American thoroughfares are famed. To form a smooth and durable pavement, the pitching-stones should have a considerable depth, and their opposite sides ought to be as nearly parallel as possible, or, in other words, the stones should have very little taper. The footpaths in most of the towns are paved with bricks set on edge, and bedded in sand, similar to the 'clinkers,' or small hard-burned bricks so generally used for road-making in Holland.

"The second specimen was formed with broken stones, but the materials, owing chiefly, no doubt, to the high rate of wages, are not broken sufficiently small to entitle it to the name of a 'Macadamized road.' It is, however, a wonderful improvement on the ordinary pitched pavement of the country, and the only objections

to its general introduction are the prejudicial effects produced on it by the very intense frost with which the country is visited, and the expense of keeping it in repair.



"The third specimen is rather of an original description. It consists of a species of tesselated pavement, formed of hexagonal billets of pine wood measuring six inches on each side, and twelve inches in depth, arranged as shown in the annexed cut, in which the larger diagram is a view of part of the surface of the pavement, and the smaller, one of the billets of wood of which it is composed, shown on a larger scale. From the manner in which the timber is arranged, the pressure falls on it parallel to the direction in which its fibres lie, so that the tendency to wear is very small. The blocks are coated with pitch or tar, and are set in sand, forming a smooth surface for carriages, which pass easily and noiselessly over it. There can be no doubt of the suitableness of wood for forming a roadway; and such an improvement is certainly much wanted in all American towns, and in none of them more than in New York. Some, however, have expressed a fear that great difficulty would be experienced in keeping pavements constructed in this manner in a clean state, and that during damp weather a vapor might arise from the timber, which, if it were brought into general use, would prove hurtful to the salubrity of large towns.

"In the northern parts of Germany and also in Russia, wooden pavements are a good deal used. My friend Dr. D. B. Reid informs me, that at St. Petersburg a wooden causeway has been tried with considerable success. The billets of wood are hexagonal, and are arranged in the manner represented in the diagram of the American pavement. At first they were simply imbedded in the ground, but a great improvement has been introduced by placing them on a flooring of planks laid horizontally, so as to prevent them from sinking unequally. This has not, so far as I know been done in America."

Archimedes.

This celebrated philosopher of antiquity was a native of Syracuse in Sicily, and is supposed to have been born about two hundred and eighty years before the commencement of the Christian era.

In proof of Archimedes' knowledge of the doctrines of specific gravities, a singular fact is related in Vitruvius. Hiero, king of Syracuse, suspecting that in making a golden crown which he had ordered, the workmen had stolen part of the gold, and substituted in its stead an equal weight of silver, he applied to Archimedes, entreating him to exercise his ingenuity in detecting the fraud. Contemplating the subject one day as he was in the bath, it occurred to him that he displaced a quantity of water equal to the bulk of his own body. Quitting the bath with that eager and impetuous delight which a new discovery naturally excites in an inquisitive mind, he ran naked into the street, crying, *Eureka! Eureka!* [I have found it out! I have found it out!] Procuring a mass of gold, and another of silver, each of equal weight with the crown, he observed the quantity of fluid which each displaced, successively, upon being inserted in the same vessel full of water; he then observed how much water was displaced by the crown; and, upon comparing this quantity with each of the former, soon learned the proportions of silver and gold in the crown

In mechanics and optics the inventive powers of Archimedes were astonishing. He said, with apparent, but only apparent, extravagance, "*Give me a place to stand upon, and I will move the earth;*" for he perfectly understood the doctrine of the lever, and well knew, that, theoretically, the greatest weight may be moved by the smallest power. To show Hiero the wonderful effect of mechanic powers, he is said, by the help of ropes and pulleys, to have drawn towards him, with perfect ease, a galley which lay on shore, manned and loaded. But the grand proofs of his skill were given during the siege of Syracuse by Marcellus. Whether the vessels of the besiegers approached near the walls of the city, or kept at a considerable distance, Archimedes found means to annoy them. When they ventured closely under the rampart raised on the side towards the sea, he, by means of long and vast beams, probably hung in the form of a lever, struck with prodigious force upon the galleys, and sunk them: or by means of grappling hooks at the remote extremity of other levers, he caught up the vessels into the air, and dashed them to pieces against the walls or the projecting rocks. When the enemy kept at a greater distance, Archimedes made use of machines, by which he threw from behind the walls stones in vast masses, or great numbers, which shattered and demolished the ships or the machines employed in the siege. This mathematical Briareus, as Marcellus jestingly called him, employed his hundred arms with astonishing effect. His mechanical genius was the informing soul of the besieged city; and his powerful weapons struck the astonished Romans with terror

One, in particular, consisting of a mirror, by which he concentrated the rays of the sun upon the besieging vessels and set them on fire, must have produced an extraordinary impression upon those who suffered from it, seeing that it was of so wonderful a character as to be thought a fiction by subsequent ages, until its reality was proved by the repetiton of the experiment. Buffon contrived and made a burning-glass, composed of about four hundred glass planes, each six inches square, so placed as to form a concave mirror, capable of melting silver at the distance of fifty feet, and lead and tin at the distance of one hundred and twenty feet, and of setting fire to wood at the distance of two hundred feet; and the story of Archimedes' instrument for burning ships at a great distance was no longer ridiculed.

Eminent as Archimedes was for his skill and invention in mechanics, his chief excellence, perhaps, lay in the rare talent which he possessed of investigating abstract truths, and in inventing conclusive demonstrations in the higher branches of pure geometry. If we are to credit the representation of Plutarch, he looked upon mechanic inventions as far inferior in value to those intellectual speculations which terminate in simple truth, and carry with them irresistible conviction. Of his success in these lucubrations, the world is still in possession of admirable proofs in the geometrical treatises which he left behind him. Of the unremitting ardor with which he devoted himself to mathematical studies, and the deep attention with which he pursued them, his memoirs afford striking and interesting examples. It is related of him, that he was often so totally absorbed in mathematical speculations, as to neglect his meals and the care of his person. At the bath he would frequently draw geometrical figures in the ashes, or, when according to the custom he was anointed, upon his own body. He was so much delighted with the discovery of the ratio between the sphere and the containing cylinder, that, passing over all his mechanic inventions, as a memorial of this discovery, he requested his friends to place upon his tomb a cylinder, containing a sphere, with an inscription expressing the proportion which the containing solid bears to the contained.

No sincere admirer of scientific merit will read without painful regret, that when Syracuse, after all the defence which philosophy had afforded it, was taken by storm, and given up to the sword, notwithstanding the liberal exception which Marcellus had made in favor of Archimedes, by giving orders that his house and his person should be held sacred, at a moment when this great man was so intent upon some mathematical speculation as not to perceive that the city was taken, and even when, according to Cicero, he

was actually drawing a geometrical figure upon the sand, an igno rant barbarian, in the person of a Roman soldier, without allowing him the satisfaction of completing the solution of his problem, ran him through the body. This event, so disgraceful to the Roman character and to human nature, happened two hundred and twelve years before Christ. It was a poor compensation for the insult offered by this action to science in the person of one of her most favored sons, that Marcellus, in the midst of his triumphal laurels, lamented the fate of Archimedes, and, taking upon himself the charge of his funeral, protected and honored his relations. The disgrace was in some measure cancelled, when Cicero, a hundred and forty years afterwards, paid homage to his forgotten tomb. "During my quæstorship," says this illustrious Roman, "I diligently sought to discover the sepulchre of Archimedes which the Syracusans had totally neglected, and suffered to be grown over with thorns and briers. Recollecting some verses, said to be inscribed upon the tomb, which mentioned that on the top was placed a sphere with a cylinder, I looked round me upon every object at the Agragentine Gate, the common receptacle of the dead. At last I observed a little column which just rose above the thorns, upon which was placed the figure of a sphere and cylinder. This, said I to the Syracusan nobles who were with me, this must, I think, be what I am seeking. Several persons were immediately employed to clear away the weeds and lay open the spot. As soon as a passage was opened, we drew near, and found on the opposite base the inscription, with nearly half the latter part of the verses worn away. Thus would this most famous, and formerly most learned city of Greece, have remained a stranger to the tomb of one of its most ingenious citizens, had it not been discovered by a man of Arpinum."

The Inventor of the Iron Plough.

Since the beginning of the present century, the wooden plough has very generally been supplanted in Scotland, and in a considerable degree in England, America, and other parts of the world, by a similar implement formed of iron. This change, indeed, is irresistible, as not only is the latter implement more durable, but, being lighter, more convenient, and less liable to get out of order, it produces a great saving in time and labor.

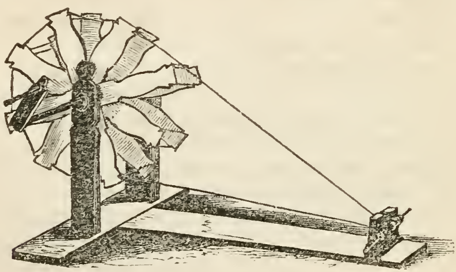
We have been informed that the author of this great and sudden improvement upon a machine which may be said to have continued unchanged for thousands of years, was William Allan, of Stone-

house, in Lanarkshire, Scotland, a man of considerable activity of mind, and inventive genius, but in all other respects a simple and unambitious peasant. He was the son of a country farrier and smith, and brought up as a farmer. Falling, at his father's death, into the possession of his tools, he was led, by a natural bent towards the mechanical arts, to attempt various improvements upon the rustic implements which he used. In the winter of 1803–4, he first conceived the daring idea of altering the material of the plough to iron, and with his own hands constructed one of that metal, which he thenceforward used on his own farm. "William Allan's Iron Plough," instantly acquired local fame, and people came from all parts of the district to see it. Its celebrity continued to extend, until enlightened persons at a distance heard of it, and were also attracted in considerable numbers to witness its operations. Mr. Campbell of Shawfield was the first patron of agricultural improvement who ventured to have one made. He thought it would be a suitable implement for his Highland farms, and requested Allan to make one for him, with the view of having others if the first should give satisfaction. But Allan, though a constant dabbler in iron work, could not allow himself to think so well of his abilities in that line, as to undertake the construction of a plough for so great a man as Mr. Campbell; and he recommended that Mr. Gray, a respectable blacksmith at the neighboring village of Uddingston, should be employed to execute the job.

Gray accordingly made an iron plough for Mr. Campbell, under the directions of the inventor; and the article being found satisfactory, he was immediately employed to make others. Ere long, orders came so fast upon him for iron ploughs, that, not having sufficient capital for his increased business, he was obliged to take in a moneyed partner. For some time the manufacture of iron ploughs was limited to this little village; but at length other artificers throughout the kingdom ventured to make them too, and, in time, they were found universally diffused. As might be expected, several improvements were made upon the first comparatively rude attempt of William Allan; but the principle in all cases remained unaltered. In the mean time, while so many were profiting by the manufacture of the article, and while the whole nation was a gainer by its economy and durability, the simple inventor remained in his obscurity, contented with the reflection that he had done his country *some service*.

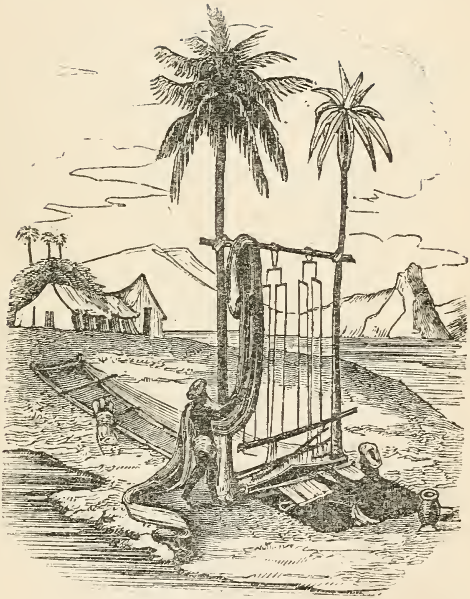
Cotton manufacture of India.

The cotton manufacture of India is not carried on in a few large towns, or in one or two districts; it is universal. The growth of cotton is nearly as general as that of food; everywhere the women spend their time in spinning, and almost every village contains its weavers, who supply the inhabitants with the scanty clothing they require. Being a domestic manufacture, and carried on with the rudest and cheapest apparatus, it requires neither capital or mills, nor an assemblage of various trades. The cotton is separated from the seeds by a small rude hand-mill or gin, which is turned by a woman. This mill consists of two rollers of teak-wood fluted lengthwise, with five or six grooves, and revolving nearly in contact. The upper roller is turned by a handle, and the lower is carried along with it by means of a perpetual screw at the axis. The cotton is put in at one side, and drawn through by the revolving rollers; the seeds being too large to pass through the opening, are torn off and fall down on the opposite side from the cotton. The next operation is that of bowing the cotton, to clear it from knots and dirt. A large bow, made elastic by a complication of strings, is used; this being put in contact with a heap of cotton, the workman strikes the string with a heavy wooden mallet, and its vibrations open the knots of the cotton, shake from it the dirt, and raise it to a downy fleece. The hand-mill and bow have been used immemorially throughout all the countries of Asia. The cotton being thus prepared, without any carding, it is spun by the women; the coarse yarn is spun on a heavy one-thread wheel of the rudest carpentry, made of teak-wood.



INDIAN SPINNING-WHEEL.

The finer yarn is spun with a metallic spindle, sometimes with and sometimes without a distaff; a bit of clay is attached as a



HINDOOS WEAVING.

weight to one end of the spindle, which is turned round with the left hand while the cotton is supplied with the right; the thread is wound up on a small piece of wood. The spinster keeps her fingers dry by the use of a chalky powder. In this simple way the Indian women, whose sense of touch is most acute and delicate, produce yarns which are finer and far more tenacious than any of the machine spun yarns of Europe.

The yarn having been reeled and warped in the simplest possible manner, is given to the weaver, whose loom is as rude an apparatus as can be imagined; consisting merely of two bamboo rollers for the warp and web, and a pair of gear. The shuttle performs the double office of shuttle and batten, and for this purpose is made like a large netting needle, and of a length somewhat exceeding the breadth of the piece. This apparatus the weaver carries to a tree, under which he digs a hole large enough to contain his legs and the lower part of his gear. He then stretches his warp by fastening the bamboo rollers at a due distance from each other on the turf by wooden pins; the balances of the gear he fastens to some convenient branch of the tree over his head; two loops underneath the gear, into which he inserts his great toes, serve instead of treadles, and his long shuttle, which also performs the office of batten, draws the weft through the warp, and afterwards strikes it up close to the web. There is not so much as an expedient for rolling up the warp; it is stretched out at the full length of the web, which makes the house of the weaver insufficient to contain him. He is therefore obliged to work continually in the open air, and every return of inclement weather interrupts him.

It cannot but seem astonishing, that in a department of industry where the raw material is so grossly neglected, the machinery so rude, and the division of labor so little, that the results should be fabrics of the most exquisite delicacy and beauty, unrivalled by the products of other nations, even those best skilled in the mechanic arts. This anomaly is explained by the remarkably fine sense of touch possessed by that effeminate people, their patience and gentleness, and by the hereditary continuance of a particular species of manufacture in families through many generations, which leads to the training of children from their very infancy in the processes of the art. The rigid, clumsy fingers of an European would scarcely be able to make a piece of canvass with the instruments which are all that an Indian employs in making a piece of cambric (muslin.) It is farther remarkable, that every distinct kind of cloth is the production of a particular district, in which the fabric has been transmitted, perhaps for centuries, from father to

son. The unequalled manual skill of the Indian weaver may be thus explained :—It is a sedentary occupation, and thus in harmony with his predominant inclination ; it requires patience, of which he has an inexhaustible fund ; it requires little bodily exertion, of which he is always exceedingly sparing ; and the finer the production, the more slender the force he is called upon to apply. But this is not all : the weak and delicate frame of the Hindoo is accompanied with an acuteness of external sense, particularly of touch, which is altogether unrivalled, and the flexibility of his fingers is equally remarkable. The hand of the Hindoo, therefore, constitutes an organ adapted to the finest operations of the loom, in a degree which is almost, or altogether, peculiar to himself.

It is, then, to a physical organization in the natives, admirably suited to the processes of spinning and weaving ; to the possession of the raw material in the greatest abundance ; to the possession, also, of the most brilliant dyes for staining and printing the cloth ; to a climate that renders the colors lively and durable ; and to the hereditary practice by particular castes, classes, and families, both of the manual and chemical processes required in the manufacture ; it is to these causes, with very little aid from science, and in an almost barbarous state of the mechanical arts, that India owes her long supremacy in the manufacture of cotton.

One fact strikingly manifests the national character of this people. It is said that all the Indian weavers, who weave for common sale, make the woof of one end of the cloth *coarser* than that of the other, and attempt to *sell* to the unwary *by the fine end*, although almost every one who deals with them is perfectly aware of the circumstance ; and it is, therefore, a rare chance if a single opportunity occurs to the weaver to gain by this means during the whole course of his life !

Description of the Bridge at the Niagara Falls.

The bridge across the rapids of the river Niagara is placed only two or three hundred yards from the edge of the great falls. It extends from the American bank of the river to Goat Island, which separates what is called the " American " from the " British fall." The superstructure of the bridge is formed of timber. It is 396 feet in length, and is supported on six piers, formed partly of stone and partly of wood. When I visited the falls of Niagara in the month of May, the ice carried down from Lake Erie by the rapids of the river was rushing past the piers of this bridge with

a degree of violence that was quite terrific, and seemed every moment to threaten their destruction.

The following very interesting account of this work is given by Captain Hall:—

"The erection of such a bridge at such a place is a wonderful effort of boldness and skill, and does the projector and artist, Judge Porter, the highest honor as an engineer. This is the second bridge of the kind; but the first being built in the still water at the top of the rapids, the enormous sheets of ice, drifted from Lake Erie, soon demolished the work, and carried it over the falls. Judge Porter, however, having observed that the ice in passing along the rapids was speedily broken into small pieces, fixed his second bridge much lower down, at a situation never reached by the larger masses of ice.

"The essential difficulty was to establish a foundation for his piers on the bed of a river covered with huge blocks of stone, and over which a torrent was dashing at the rate of six or seven miles an hour. He first placed two long beams, extending from the shore horizontally forty or fifty feet over the rapids, at the height of six or eight feet, and counterbalanced by a load at the inner ends. These were about two yards asunder; but light planks being laid across, men were enabled to walk along them in safety. Their extremities were next supported by upright bars passed through holes in the ends, and resting on the ground. A strong open frame-work of timber, not unlike a wild beast's cage, but open at top and bottom, was then placed in the water immediately under the ends of the beams. This being loaded with stones, was gradually sunk till some one part of it—no matter which—touched the rocks lying on the bottom. As soon as it was ascertained that this had taken place, the sinking operation was arrested, and a series of strong planks, three inches in thickness, were placed, one after the other, in the river, in an upright position, and touching the inner sides of the frame-work. These planks, or upright posts, were now thrust downwards till they obtained a firm lodgment among the stones at the bottom of the river; and, being then securely bolted to the upper part of the frame-work, might be considered parts of it. As each plank reached to the ground, it acted as a leg, and gave the whole considerable stability, while the water flowed freely through openings about a foot wide, left between the planks.

"This great frame or box, being then filled with large stones tumbled in from above, served the purpose of a nucleus to a larger pier built round it, of much stronger timbers firmly bolted together, and so arranged as to form an outer case, distant from the first pier

about three feet on all its four sides. The intermediate space between the two frames was then filled up by large masses of rock. This constituted the first pier.

" A second pier was easily built in the same way, by projecting beams from the first one, as had been previously done from the shore; and so on, step by step, till the bridge reached Goat Island. Such is the solidity of these structures, that none of them has ever moved since it was first erected, several years before we saw it."

Thomas Godfrey,

The inventor of the Quadrant, was born in the year 1704, near Germantown, Pennsylvania. Losing his father when very young, and his mother marrying again, he was put out to learn the business of a painter and glazier at Stanton, a village in the neighborhood of Philadelphia.

Very little has been preserved respecting his history. From all accounts he must have been a person of considerable ingenuity. His affection for mathematics occurred at an early period from a chance opportunity of reading a book on that science. Finding the subject perplexed with Latin terms, he applied himself with such diligence as to overcome the difficulty arising from this source.

It is related that when Sir Isaac Newton's celebrated mathematical work made its appearance, the best scholars were obliged to study it with care, and those of a lower rank durst not venture upon it at all. The American glazier, without encouragement from any quarter, and wholly self-taught, ventured upon and mastered this great work at an early age, and finally, with the embarrassments of an humble trade and extreme poverty, produced one of the most useful of instruments.

There has been heretofore considerable controversy existing, as to whom belonged the honor of this invention. The conclusion now is, that Hadley and Godfrey invented their instruments nearly simultaneously and independently. While the Englishman, with every advantage of pursuit, " stumbled upon" the invention, and is honored in its name, to our countryman belongs the true glory, for his was the result of unassisted genius, acting under adverse circumstances.

Peace to his ashes: although no storied urn or monumental bust marks the spot of his repose, yet his memory will live as long as his country preserves a just sense of the merits of her sons, or the wings of commerce spread the sea.

Musical Kaleidescope.

Some years ago an attempt was made—it was said, successfully—to produce tunes on a principle not unlike that by which the kaleidescope was made to produce carpet and shawl patterns. The materials employed for the purpose consisted of prepared cards, on each of which a bar of an air was arranged according to a certain rhythm and key. Four packs of these cards, marked A, B, C, and D, were mingled together, and the cards were drawn and arranged before a performer at random. Thus an original air was obtained. The plan was said to succeed particularly well in waltzes.

Bernard Palissy.

The celebrated Bernard Palissy, to whom France was indebted, in the sixteenth century, for the introduction of the manufacture of enamelled pottery, had his attention first attracted to the art, his improvements in which form to this time the glory of his name among his countrymen, by having one day seen by chance a beautiful enamelled cup, which had been brought from Italy. He was then struggling to support his family by his attempts in the art of painting, in which he was self-taught; and it immediately occurred to him that, if he could discover the secret of making these cups, his toils and difficulties would be at an end. From that moment his whole thoughts were directed to this object; and in one of his works he has himself given us such an account of the unconquerable zeal with which he prosecuted his experiments, as it is impossible to read without the deepest interest.

For some time he had little or nothing to expend upon the pursuit which he had so much at heart; but at last he happened to receive a considerable sum of money for a work which he had finished, and this enabled him to commence his researches. He spent the whole of his money, however, without meeting with any success, and he was now poorer than ever. Yet it was in vain that his wife and his friends besought him to relinquish what they deemed his chimerical and ruinous project. He borrowed more money, with which he repeated his experiments; and, when he had no more fuel wherewith to feed his furnaces, he cut down his chairs and tables for that purpose. Still his success was inconsiderable. He was now actually obliged to give a person, who had assisted him, part of his clothes by way of remuneration,

having nothing else left; and, with his wife and children starving before his eyes, and by their appearance silently reproaching him as the cause of their sufferings, he was at heart miserable enough. But he neither despaired nor suffered his friends to know what he felt; preserving, in the midst of all his misery, a gay demeanor, and losing no opportunity of renewing his pursuit of the object which he all the while felt confident he should one day accomplish. And at last, after sixteen years of persevering exertion, his efforts were crowned with complete success, and his fortune was made. Palissy was, in all respects, one of the most extraordinary men of his time; in his moral character displaying a high-mindedness and commanding energy altogether in harmony with the reach and originality of conception by which his understanding was distinguished.

Although a Protestant, he had escaped, through the royal favor, from the massacre of St. Bartholomew; but, having been soon after shut up in the Bastile, he was visited in his prison by the king, who told him, that if he did not comply with the established religion, he should be forced, however unwillingly, to leave him in the hands of his enemies. "Forced!" replied Palissy. "This is not to speak like a king; but they who force you cannot force me; I can die! Your whole people have not the power to compel a *simple potter to bend his knee!*" He never regained his liberty, but ended his life in the Bastile, in the ninetieth year of his age.

Dyeing Cloth of two Colors.

The following method of dyeing the opposite sides of cloth different colors, is practised by the manufacturers:—A paste is prepared of the finest flour, which is spread on one side: the cloth is then doubled, and the edges closely sewn together: on its immersion in the heated dye the enclosed air expands, and none of the coloring matter affects the inside of the cloth. When this process is completed, the cloth is unsewn, a paste spread on the side already dyed, and the same method is pursued with regard to the other color.

Remarkable Wooden Bridge.

Near Rochester, in the state of New-York, there are the remains of a bridge over the Genessee river, called Clyde Bridge,

which, when entire, was altogether unrivalled by any thing of a similar kind, either in America or Europe. It consisted of a single arch of three hundred and fifty-two feet span, and one hundred and ninety-six feet high, from the surface of the river. It was seven hundred and eighteen feet long, and thirty wide; and, though the whole structure contained more than one hundred and thirty thousand feet of timber, it was completed by twenty workmen in the space of nine months. Dr. Howison, who visited it about the year 1830, gives the following description of its then ruined state:—"The road I took led me to the edge of the cliffs that confine the Genessee river: this stream roared ninety feet beneath me, and a half arch stretched far above my head, as it were 'suspended in mid air,' while on the opposite cliffs heaps of planks, shattered beams, and many massy supporters, lay in horrible confusion, being the remains of that part of the structure which had fallen. Nothing can exceed the exquisite, the elegant proportions, and the aerial magnificence of that part of the bridge which remains entire. Its complicated architecture, the colossal span of its arch, its appalling height above the surface of the water, and the noble scenery around, fill the mind with astonishment. A little way up the river, the lesser Genessee rushes over broken rocks, while the woods which bound the prospect on all sides, and darkly overshadow the hoary cliffs, communicates a wildness to the scene, that makes the imaginative spectator almost believe that the bridge above him has been raised by the spells of a magician, rather than by the hands of man."

Celebrated and Curious Clocks.

About the year 1369, an artist named James Dondi, constructed a clock for the city of Padua, by order of Herbert, Prince of Carara, which was long considered the wonder of that age. This is the first clock on record having its dial-plate divided into twenty-four hours, (day and night;) but it has been disputed, (as is common in all first inventions,) whether or not Dondi, who was afterwards called Horologius, was the original inventor; this clock, besides indicating the hours, represented the motions of the sun, moon, and planets, and also pointed out the different festivals of the year.

The celebrated clock in the cathedral church of Strasburg, has been long celebrated for the great variety and complication of its movements; it was begun some time in the year 1352, and erected into the spire of the cathedral in the year 1370. The follow-

ing is a short description of this singular piece of mechanism: On the dial-plate was exhibited a celestial globe, with the motions of the sun, moon, earth, and planets, and the various phases of the moon; also a sort of perpetual almanac, on which the day of the month was pointed out by a statue. It had a golden cock which on the arrival of every successive hour flapped its wings, stretched forth its neck, and crowed twice! The hour was struck on the bell by a figure representing an angel, who opened a door and saluted a figure of the Virgin Mary. Near him stood another angel, who held an hour-glass, which he turned as soon as it had finished striking. The first quarter of the hour was struck by a child with an apple, the second quarter by a youth with an arrow, the third quarter by a man with the tip of his staff, and the fourth and last quarter by an old man with his crutch.

This celebrated clock has, however, been much altered from the original, if not entirely renewed, by Conrad Dasypodius, professor of mathematics in the University of Strasburg. It was finished in the space of three years, having been begun in May, 1571, and finished June 24th, 1574. After it was replaced in the spire of the cathedral, it exhibited the following particulars:—The basement of the clock showed three dial-plates, one of which was round, and made up of several concentric circles; the two interior ones perform their revolutions in a year, and thus serve as a calendar; the two lateral dial-plates are squares, and serve to indicate the eclipses of the sun and moon Above the middle dial-plate, the days of the week are represented by different divinities, supposed to preside over the planets from which their common appellations are derived. The divinity of the current day appears in a car rolling over the clouds, and at midnight retires to give place to the succeeding one. Before the basement a globe is displayed, borne on the wings of a pelican, round which the sun and moon are made to revolve, and consequently represents the motion of those bodies. The ornamental turret above said basement exhibits a large dial in the form of an astrolabe, which shows the annual motion of the sun and moon through the ecliptic, as also the hours of the day, etc. The phases of the moon are also marked on a dial-plate above. Over this dial-plate are represented the four ages of man by symbolical figures, one of which passes every quarter of an hour, and marks this division of time by striking on small bells, (as in the old clock.) Two angels are also seen in motion, one striking a bell with a sceptre, while the other turns an hour-glass at the expiration of every hour. This celebrated clock has lately undergone repair.

According to Dr. Derham, the oldest English made clock extant

is the one placed in the principal turret of the Palace Royal, Hampton Court, near London; it was constructed in the year 1540, by a maker of the initials of N. O.

Some time about the year 1560, the celebrated Danish astronomer, Tycho Brahe, was in possession of four clocks, which indicated the hours, minutes, and seconds; the largest of which had only three wheels, one of which was about three feet in diameter, and had twelve hundred teeth in it; a proof that clock-work was then in a very imperfect state. Tycho, however, observed that there were some irregularities in the going of his clocks, which depended upon the changes of the atmosphere; but he does not appear to have known how such an effect was produced, so as to apply some remedy to cure the evil.

Moestlin had a clock in the year 1577, so constructed as to make just two thousand five hundred and twenty-eight beats in an hour, one hundred and forty-six of which were counted during the sun's passage over a meridian, or azimuth line, and thereby determined his diameter to be 34′ 13″; so the science of astronomy began thus early to be promoted by clock-work; and as clocks first promoted the study of astronomy, it will be observed that astronomy in its turn gave rise to some of the most essential improvements in clock-work, and that the arts and sciences were more and more cultivated as improvements in clock-work kept pace with them, and employed the talents of the most ingenious men of every succeeding age.

Mr. Ferguson, in his Select Mechanical Exercises, describes two very curious clocks of his invention and construction; namely, a clock for showing the mean apparent diurnal motions of the sun and moon, the age and phases of the moon, with the mean time of her meridian passage, and the times of high and low water; all of these particulars being exhibited by having only two wheels and one pinion added to the common clock movement; in this clock the figure of the sun serves as an hour index, by going round the dial in twenty-four hours, and a figure of the moon goes round in twenty-four hours and fifty and a half minutes, being nearly the period of her revolution in the heavens from any meridian to the same meridian again. It has been remarked, that this clock must have been modelled by Mr. Ferguson from the fashion of the celebrated clock at Hampton Court. The other clock by Mr. Ferguson is an astronomical one, showing the mean apparent daily motions of the sun, moon, and stars, with the mean times of their rising, southing, and setting; the places of the sun and moon in the ecliptic, and the age and phases of the moon for every day in the year

"On Monday, April 27th, 1762," says Wesley, in his journal

"being at Lurgan, in Ireland, I embraced the opportunity which I had long desired of talking with Mr. Miller, the contriver of that statue which was in Lurgan when I was there before. It was the figure of an old man standing in a case, with a curtain drawn before him, over against a clock which stood on the opposite side of the room. Every time the clock struck, he opened the door with one hand, drew back the curtain with the other, turned his head as if looking round on the company, and then said with a clear, loud, articulate voice, "*past one*," or "*two*," or "*three*," and so on. But so many came to see this, (the like of which all allowed was not to be seen in Europe,) that Mr. Miller was in danger of being ruined; not having time to attend to his own business. So, as none offered to pay him for his pains, he took the whole machine to pieces.

In the gardens of the Palais Royal and the Luxembourg, at Paris, is a *cannon clock;* a contrivance invented by one Rosseau. A burning-glass is fixed over the vent of a cannon, so that the sun's rays, at the moment of its passing the meridian, are concentrated on the priming, and the piece is fired. The glass is regulated for this purpose every month.

It is now time to mention a clock of almost miraculous properties, constructed by a Genevan mechanic of the name of Droz, towards the end of the last century. The clock in question was so constructed as to be capable of performing the following surprising movements, (if the account can be credited:)—There was exhibited on it a negro, a shepherd, and a dog. When the clock struck, the shepherd played six tunes on his flute, and the dog approached and fawned upon him. This clock was exhibited to the king of Spain, who was greatly delighted with it. "The gentleness of my dog," said Droz, "is his least merit. If your majesty touch one of the apples which you see in the shepherd's basket, you will admire the fidelity of this animal." The king took an apple, and the dog flew at his hand, and barked so loud, that the king's dog, which was in the same room during the exhibition, began to bark also; at this, the courtiers, not doubting that it was an affair of witchcraft, hastily left the room, crossing themselves as they went out. The minister of marine, who was the only one who ventured to stay behind, having desired him to ask the negro what o'clock it was, the minister staid, but he obtained no reply. Droz then observed, that the negro had not yet learned Spanish, upon which the minister repeated the question in French, and the black immediately answered him. At this new prodigy the firmness of the minister also forsook him, and he retreated precipitately, declaring that it must be the work of a supernatural being.

The last clock which I shall mention at present is one which I contrived and executed some five or six years ago. It shows the hour of the day, the mean time of the rising, southing, and setting of the sun and moon, the moon's age and phases throughout the year, (by having an horizon which expands and contracts by means of the complicated wheel-work,) the day of the month, the mean time of the sun's entering into the zodiacal signs, sidereal and solar year, and consequently, the precession of the equinoxes, which in the clock has a slow backward motion through the ecliptic in 25,920 years; the flux and reflux of the tides are also exhibited in the arc of the dial-plate; the movement contains somewhere about fifty-six wheels, sixteen pinions, nine levers for various uses, and about one hundred and thirty moveable pieces; it goes for eight days, has what is called a dead beat scapement, and goes while winding up.

Horology is a branch of knowledge most intimately connected with astronomy, navigation, and chronology, and its usefulness is found linked more or less with all of the most important branches of science. Without a proper understanding of horology, the mariner could not with safety plough the ocean; he could not calculate with accuracy his distance from land; and in fine, without horology, history would appear without dates, and even the more common affairs of domestic life would run into confusion. The clock of early times was of very rude construction; and it would seem from what remains of their history, that a loss or gain of five, ten, twenty, or more minutes per day, was not much regarded; and if it kept within these wide bounds, the horologe was looked upon as "a miracle of art." But now, in modern times, when the art of horology has risen to such perfection that in astronomical clocks, with compensation pendulums of right principles, a gain or loss of five minutes in a year would by no means answer the present advanced state of the sublime science of astronomy, neither would it in this state much further the art of navigation, in the prediction of a ship's way on the ocean. From the duplicate of an official statement now lying before me, it is stated that the Lords Commissioners of the Admiralty, having advertised a premium of £300 for the best chronometer which should be kept at Greenwich Observatory for trial for one year, thirty-six were forwarded by the principal chronometer makers in London, and were kept during the year 1823. It was announced that if any chronometer varied six seconds, it could not obtain the prize at the end of the year. The chronometer marked 816 gained the prize, having kept time for many months within "*one second and one eleven hundredth part of a second!*" This is certainly the best chronometer on

record. Such perfection was never before attained, and it justly excited the astonishment of all astronomers, and of the Board of Admiralty.

Manufacture of Earthenware and Porcelain.

> "Etruria! next beneath thy magic hands
> Glides the quick wheel, the plastic clay expands:
> Nerved with fine touch, thy fingers, as it turns,
> Mark the nice bounds of vases, ewers, and urns;
> Round each fair form, in lines immortal trace
> Uncopied beauty and ideal grace." DARWIN.

The business of creating from a mass of clay "vases, ewers, and urns," which, in the homely language of the potter, is termed *throwing*, has always excited admiration. One moment, an unfashioned lump of earth is cast on the block; the next, it is seen starting into forms of elegance and beauty. A simple wheel, and hands untutored in other arts, effect this wondrous change. The means appear to be scarcely adequate to the end; and thence the poet, with seeming truth, asserts that "magic hands" perform this work of art.

The remotest ages of antiquity lay claim to the invention of earthenware;—probably it was carried to a higher point of improvement than any other of the early manufactures of the world. It could originate only in those regions which produced its essential materials, and thus we find no vestiges of its having existed in countries where clay is unknown. In America, while some regions possess curious specimens of ancient pottery, others, in which the raw material has not been found, present no such antique remains. The natives of these latter countries have availed themselves of such substitutes as nature has provided. The gourd, called calabash, which they ingeniously carve and cut into various forms, affords them as abundant a supply of vessels for holding liquids as their simple modes of life require.

The plastic power of clay was early discovered. It appears to have been employed in the most ancient times, as it still is in Egypt, to receive the impression of a seal, the affixing of which on property was probably considered, even at that period, as a legal protection. Job, in one of his poetic similes, says, (chap. xxxviii, 14,) "It is turned as clay to the seal."

Many centuries before the art was practised in Europe, the Chinese had brought it very nearly to the degree of perfection which their porcelain now exhibits. In this one branch of art they have undisputed possession of materials of the most perfect

combination of colors, of unrivalled brilliance, but of "ideal grace" not one particle.

From Asia this art entered Europe through Greece, the land of "creative genius." The Corinthian potters especially displayed, in their designs and execution, exquisite taste and skill. Their works were more prized than diamond or ruby, and were amongst the most valuable decorations in the dwellings of princes. Greece, supplying with porcelain Egypt, the mother country of so many other arts, at length taught it to establish its own pottery, and, spreading the useful art far and wide, to become itself the benefactor of other regions.

A Phœnician colony, it is supposed, founded the ancient Etruria, whence modern Europe has drawn models of skill and beauty.

Though conquerors ought seldom to be regarded as benefactors, the Romans in many instances were such to the nations they subdued. Wherever they obtained a permanent empire, they planted their arts and manufactures. Though some maintain that Phœnicia supplied Britain with earthen vessels in exchange for its metals, there are so many vestiges of Roman manufactures as to corroborate the belief of her being indebted to that people for the art of the potter. In the neighborhood of Leeds the remembrance of a Roman pottery is still recorded in the name of the village which rose upon its site—*Potter Newton*.

Although introduced into Britain at so early a period, the potter's art long remained in its rudest state. The coarse red ware only was made, but was not of sufficient beauty or utility to be received as a substitute for utensils and vessels of wood and metal, as earthenware, in its improved state, has since been. In every dwelling, even the humblest, earthenware and china are now essential, and not only in England, but in all the civilized regions of the world. This change was principally effected by the industry and comprehensive mind of one individual—Josiah Wedgwood, the founder of modern Etruria. The Staffordshire potteries, which in his day consisted of a few thinly peopled villages, now present a continued chain of manufactories, extending for miles, in which tens of thousands of people are constantly employed and supported.

For centuries previous to the time of which we are speaking, the manufacture of earthenware had, in this country, remained unimproved; and in Europe, generally, it had been almost as stationary. From the east, the wealthy and luxurious of the western hemisphere were supplied with porcelain, valued on account of its rareness rather than for its beauty; while the humbler

ranks of society sought no other than metal or wooden domestic utensils, unless they added to these some of the rude works of their native potters.

At length, in France, Germany, and Italy, princes and nobles, as if ashamed of the neglect the art had experienced in the most civilized portion of the world, founded in their respective countries porcelain manufactories. These subsequently became of considerable eminence. The Sevres, Dresden, and Berlin porcelain grew in time to be the admiration of Europe, and was mingled with the works of China, which became less prized. But the benefit conferred by these royal and noble establishments was limited. Wealth was expended on them; talents were devoted to them; but their works never circulated throughout all ranks, nor effected any general change in domestic life. they have been limited to the use only of the noble and the rich.

These manufactories cannot claim the merit of such general utility as those of England, conducted by a different class of men and upon different principles. Here, unaided by the hand of power, without wealth, and sometimes almost without education, men, the founders of British manufactories, have often started from the level of humble life into prominent and commanding situations. Dispensing means of subsistence and opening prospects of improved condition to thousands, they have acquired an influence in their day which nobles might covet. Among this class of benefactors to their race, the late Josiah Wedgwood stood preeminent. His early education, as was usual in his sphere, was very limited. Education in his day was supposed to be incompatible with the habits of a man of business. The disadvantages of this narrow system were early perceived by the intelligent Wedgwood, and his first step to the eminence he afterwards attained was the education of himself. Though apprenticed to a potter, he found leisure for acquisitions in literary knowledge, which subsequently enabled him to sustain a part in the literary and philosophical society of his time.

He had no wild or irrational ambition which induced him to attempt attainments beyond his reach: this would have ended in disappointment and downfall. His dignified view was fixed to the improvement of himself and his condition by the most laudable means; and the result, after years of steady application, accompanied with great toil and anxiety, was an ample and distinguished success.

About thirty years before he commenced the foundation of his future eminence, an accident had given rise to improvement in the earthenwares of Staffordshire. A potter from Burslem, (the centre

of the potteries, and the birthplace of Mr. Wedgwood,) in travelling to London on horseback, was detained on the road by the inflamed eyes of his horse. Seeing the hostler, the horse-doctor of those times, burn a piece of flint and afterwards reduce it to a fine white powder, applying it as a specific for the diseased eyes, a notion arose in the mind of the traveller as to the possibility of combining this beautiful white powder with the clay used in his craft, so as to effect a change in the color and body of his ware. The experiment succeeded, and this was the origin of the English white-ware. It will not be foreign to our subject to remark here, how every trifling circumstance that occurs is turned to account, when the mind is seriously at work on any subject. We know that the falling of an apple, the passing of the sun's rays through a vessel of water, the swinging of a suspended lamp, casualties apparently trifling, were fraught with important discoveries, because observed by men deeply engaged in scientific investigations.

We are not presuming to place a simple potter on a footing with Newton or Galileo—men of mighty powers; but we claim for him a point of resemblance, because like them he pursued his observations with investigation and experiment, so well directed as to ensure improvement and success. This man, whose name was Ashbury, also brought to his manufactory the superior clays of Devonshire and Cornwall; and as the potter's wheel had been somewhat improved by a person named Alsager, we may consider that, though still vast and unoccupied, the field of improvement was discovered a short time before Mr. Wedgwood entered it. We must here do honor to the French philosopher and naturalist, Reaumur, who at a rather earlier period had been almost the first in forming the connection between science and the arts of life, from that time indissoluble, and ever since producing improvement to which no termination can be foreseen. Science hitherto had been regarded as an abstract pursuit—leading to little practical good, if not unfitting those engaged in it for the pursuits of life. The chemical examination which Reaumur made on oriental china, anticipated what in time the common experiments of the manufacturer might have effected, though not with equal certainty or rapidity. Upon those experiments the Royal French manufactory of Sevres was founded. This instance of the aid which science yielded to a manufacture similar to his own, was not likely to be unheeded by Mr. Wedgwood, and, accordingly, we find him effecting, in England, that union between science and his art, which Reaumur had done in France As soon as his means permitted him to deviate without pecuniary inconvenience from the beaten path, he appears to have employed men of science to aid him in

his extended views. One amiable man, Mr. Chisholm, a superior chemist of the time, devoted his whole life to this business. Under the direction of the intelligence and indefatigable spirit of Mr. Wedgwood, he proceeded day by day, from experiment to experiment, until most of the principal objects in view were attained.

Varieties of clay were sought for, and the comparative value of their properties for the manufacture in question was ascertained, together with the true proportion of calcined flint with which each variety would unite, and the degree of heat to which each could be submitted. The *glaze* also, it has been said, gave rise to a most anxious and assiduous investigation on the part of these indefatigable laborers, which ended without their attaining the object they so earnestly desired. The rude brown ware before mentioned had been always glazed with fused salt, by a process uncertain in its results, and one which, producing noxious fumes, rendered an earthenware manufactory a nuisance to its neighborhood. The improvement in this department of the manufacture led to the substitution of white lead for salt; but although the air on glazing days was no longer odious to breathe, the substitute acted as a powerful poison on those employed in this branch of the business. Every precaution which his humanity could suggest Mr. Wedgwood adopted, to prevent the injurious influence of the lead on his work-people: but the poison was too subtle; it was imbibed through the pores as well as inhaled; and paralysis often terminated the lives of those employed in glazing, or rendered a protracted existence an evil to them. Mr. Wedgwood's humane endeavors to discover another substitute for the lead were never realized, although his hopes often represented to him the possibility of its being effected. The evil still exists.

The forms and colors were no less objects of his attention than the body of his manufacture. Oxides of metals, particularly those of iron, gave him an endless variety of colors, and for his forms and ornaments he took models from the best standards of grace and beauty which the ancient world afforded him. He also employed both English and foreign artists of merit in modelling and designing. The early talent of Flaxman, and the skilful pencil of Webber, were engaged in his service; of which there are evidences in the perfect imitation of the Barbarini vase he has left behind him, and in the classic designs which decorate the beautiful imitation of jasper which he invented. Thus his manufactory comprehended every thing his art could attain; and taste, convenience, and comfort could draw thence ample gratification. Excellence was his aim—whether in the common articles of use, or in the choicer productions of his taste; and so ambitious was he

to maintain the reputation of his manufacture, that he sacrificed every article which came from the oven in an imperfect state.

Such was the eminence Wedgwood reached as a manufacturer, that he carried every thing before him. His ware displaced foreign china in his own country, and spread itself over every part of Europe—not only ornamenting the palace, but filling the cottage with means of comfort and cleanliness. No ware could be sold that had not his name stamped on each article. *Wedgwood* became a generic term—the question being also asked on the continent, "Have you any Wedgwood?" He secured this preeminence by the excellence of his productions, and not by exclusive advantages. He always steadily refused to obtain patents for his inventions, saying, "The world is wide enough for us all."

Inventors and Poets.

On reflection it will be found that mechanical invention, differs nothing from that which gives value to those pursuits considered to be more mental and refined. Homer and his Iliad, Virgil and his Æneid, Milton and his Paradise Lost, were minds and productions of the same exquisite fibre and tention, with Savary and Watt, with their engines, Huygens with his watch, Arkwright with his spinning frame, Meikle with his threshing machine, Bramah with his hydraulic press. In fact, observation frequently shows, that the power of constructing poetry and machines are united in the same individual. Hooke made verses as well as machines, and could as well have written a sonnet to his "mistress' eyebrow" as have presented his thirty-seven projects for flying. Samuel Moreland indited love songs, and sang them to his sweetheart. When total blindness had fallen on the jovial old man, he buried the effusions of his youth, considering them to be "gay deceits," and betook himself in his ninetieth year to the composition of psalms. Arkwright was famed among his customers for a light hand and an exquisite edge, and for verses which cut as keen as his razors. Watt in his youth was a rhymester, and few men in his generation read more fairy tales and poetry,—even in the meridian of his life, in the busiest period of his employment, the greater portion of his time was devoted to indulgence in this mental luxury. Few who knew the excellent Rennie, near the close of his life, would have dreamed of finding under the exterior of this inflexible man of business, an enthusiastic admirer of poetry and music. The venerable Telford, when building rough stone walls as a journeyman

mason, was an esteemed contributor to the poetical corner of the Scots Magazine. The inventor of the celebrated congreve rocket had previously "let off" many poetical squibs. Cartwright early distinguished himself for his poetical composition; but the fine taste and exalted feeling which pervade them, must yield to the exquisite invention and extensive usefulness of his power-loom.

Poets, as well as mechanics, differ in the manner in which they exhibit their conceptions. One excels in loftiness of thought, another in delicacy of perception a third pleases by his harmonious numbers, and a fourth, is esteemed for the useful tendency of his writings. Some mechanics delight in clock-work,—others in steam engines—the machines of others are polished even to a bolt head—and a ponderous mass whose jerking motion is the nuisance of a district, constructed by one whose ear is more refined than his rival manufacturers, moves with all the softness of a watch; and another applies the principles of a toy to a machine for abridging labor. There are rhymesters who will spin a fine thought through an infinity of words; there are also artist wire-drawers, who, by great skill, will draw an ounce or two of gold into a thread which will encircle the world. Your sounding, flashy, sparkling authors of a thousand brilliant nothings, are a sort of *kaleidescope* artists, whose most original, regular, and harmonious combinations, are produced by a thread of rag, a pin's head, a leaf, a bead, or a bit of crystal.

Public Works of the United States.

"At the first view, one is struck with the temporary and apparently unfinished state of many of the American works, and is very apt, before inquiring into the subject, to impute to want of ability what turns out, on investigation, to be a judicious and ingenious arrangement to suit the circumstances of a new country, of which the climate is severe,—a country where stone is scarce and wood is plentiful, and where manual labor is very expensive. It is vain to look to the American works for the finish that characterizes those of France, or the stability for which those of Britain are famed. Undressed slopes of cuttings and embankments, roughly built rubble arches, stone parapet-walls coped with timber, and canal-locks wholly constructed of that material, everywhere offend the eye accustomed to view European workmanship. But it must not be supposed that this arises from want of knowledge of the principles of engineering, or of skill to do them justice in the execution. The use of wood, for example, which may be con-

sidered by many as wholly inapplicable to the construction of canal-locks, where it must not only encounter the tear and wear occasioned by the lockage of vessels, but must be subject to the destructive consequences of alternate immersion in water and exposure to the atmosphere, is yet the result of deliberate judgment. The Americans have, in many cases, been induced to use the material of the country, ill adapted though it be in some respects to the purposes to which it is applied, in order to meet the wants of a rising community, by speedily and perhaps superficially completing a work of importance, which would otherwise be delayed, from a want of the means to execute it in a more substantial manner; and although the works are wanting in finish, and even in solidity, they do not fail for many years to serve the purposes for which they were constructed, as efficiently as works of a more lasting description.

"When the wooden locks on any of the canals begin to show symptoms of decay, stone structures are generally substituted, and materials suitable for their erection are with ease and expedition conveyed from the part of the country where they are most abundant, by means of the canal itself to which they are to be applied; and thus the less substantial work actually becomes the means of facilitating its own improvement, by affording a more easy, cheap, and speedy transport of those durable and expensive materials, without the use of which, perfection is unattainable.

"One of the most important advantages of constructing the locks of canals, in new countries such as America, of wood, unquestionably is, that in proportion as improvement advances and greater dimensions or other changes are required, they can be introduced at little cost, and without the mortification of destroying expensive and substantial works of masonry. Some of the locks on the great Erie canal are formed of stone, but had they all been made of wood, it would, in all probability, have been converted into a ship-canal long ago.

"But the locks are not the only parts of the American canals in which wood is used. Aqueducts over ravines or rivers are generally formed of large wooden troughs resting on stone pillars, and even more temporary expedients have been chosen, the ingenuity of which can hardly fail to please those who view them as the means of carrying on improvements, which, but for such contrivances, might be stopped by the want of funds necessary to complete them.

"Mr. M'Taggart, the resident engineer for the Rideau canal in Canada, gave a good example of the extraordinary expedients often resorted to, by suggesting a very novel scheme for carrying that

work across a thickly wooded ravine situate in a part of the country where materials for forming an embankment, or stone for building the piers of an aqueduct, could not be obtained but at a great expense. The plan consisted of cutting across the large trees in the line of the works, at the level of the bottom of the canal, so as to render them fit for supporting a platform on their trunks, and on this platform the trough containing the water of the canal was intended to rest. I am not aware whether this plan was carried into effect, but it is not more extraordinary than many of the schemes to which the Americans have resorted in constructing their public works; and the great traffic sustained by many of them, notwithstanding the temporary and hurried manner in which they are finished, is truly wonderful."

Manufactory of the Gobelins.

Among the curiosities of Paris, is a manufacture of tapestry, which is sustained as a sort of plaything by the nation. It is called the manufactory of the Gobelins, from the name of the dyers who commenced the works in ancient times, and established here their dye-house for coloring their worsted yarns, with which the pieces of tapestry were wrought. The most beautiful paintings are placed as patterns by the tapestry weavers, who rival the Chinese in fidelity and exactnes of imitation. An artist of spirit who may have the genius to design and finish a piece of painting upon canvass, could hardly be brought to spend one and often two years, in copying the same picture by inserting small bits of colored worsted, particle by particle, by means of the slow and tedious labors of the loom. Tapestry weaving must remain an imitative art instead of one that can confer honor on an artist for any originality, or bold touches of genius in the art of designing. Even at the moderate wages paid the workmen here, the cost of a single sheet of tapestry frequently exceeds $1400, and several years are required to complete it. So bright, vivid, and well blended are the colors of the worsted thread, that few persons at the distance of three or four yards would suppose them to be the product of the loom. The frame that contains the extended threads of the warp, is placed in a perpendicular position, and the workman is seated behind the frame; carefully arranged by his side, are hundreds of little bobbins of worsted, of every imaginable color, the shade of which are so well blended and approximated to each other, that one can hardly tell where one terminates or another begins.—These bobbins he skilfully selects and holds near the picture which he is copying,

to compare the tints. Thread by thread he proceeds, and after satisfying himself in the selection of the color, he inserts a piece of worsted yarn, perhaps in some spots not longer than one eighth of an inch, using the bobbin itself instead of a shuttle, to pass the worsted filling in and out between the threads of the warp. After effecting this operation, he breaks off the yarn and crowds it in between the thread and the warp, by the teeth of a comb; he then seeks again for another tint to correspond with the picture before him. The warp or chain is composed of white woollen threads, and the weft, of all shades of colors that are prepared on the easel of the painter. The threads of the warp are not opened by means of treadles, or harness to allow the filling to be shot between them, as in common weaving; nor is a slaie or reed employed to press down or close the threads of the weft, after it is drawn in among the threads of the warp; but the artist uses for this purpose only a sort of comb, the teeth of which, after every operation of inserting a little piece of yarn, are employed to press it down and close it together in the work. The figure of an extended arm, or of a head, is wrought by the artist before he completes the filling, composing the back-ground around it. The form of a beautiful female may thus appear to be starting up in glowing colors, amid the threads spread like a cob-web over a square frame. A hand when thus woven in advance of the texture around it, seems as if formed of flesh and blood, and thrust amid the cords of a harp to sweep the sounding strings. This costly tapestry resembles the fine worsted work, executed in single stitch, by the fair hands of the ladies in their hours of domestic relaxation. It is so delicately composed that the outlines of the figure show no angular uneven edges; the surface of the tapestry being nearly as smooth and close as that of the oil painting from which it is copied. This establishment is supported at the national charge, the sheets of tapestry are used as ornaments of the royal palaces, and sometimes as royal gifts.

March of Umbrellas.

The following anecdote from a Scotch paper is well worth preserving. " When umbrellas marched first into this quarter, (Blairgorie,) they were sported only by the minister and the laird, and were looked upon by the common class of people as perfect phenomena. One day Daniel M—n went to Colonel McPherson, at Blairgorie House: when about to return, it came on a shower, and the colonel politely offered him the loan of an umbrella, which was politely and proudly accepted; and Daniel, with his head two or

three inches higher than usual, marched off. Not long after he had left, however, to the colonel's surprise, he sees Daniel posting towards him with all possible haste, still o'ertopped by his *cotton canopy*, (silk umbrellas were out of the question in those days,) which he held out saluting him with, "*Hae, hae, Kurnel! this 'll never do*; *there 's no a door in a' my house that 'll tak' it in—my verra barn-door winna tak' it in.*"

The French Machine Maker.

It is not long ago that I went to visit an interesting old man, who lives by the side of the Rhone, at a short distance from Lyons. Have you ever heard of the *Jacquard machine*, one of the most ingenious of modern discoveries, by which the most complicated patterns can be woven with the same ease as the plainest; a machine which enables an ordinary weaver to produce all those many-colored oriental shawls, fashionable silks, and variegated ribbands, which formerly required a dexterity possessed only by a very few, and a continuous labor that made them costly and inaccessible to any but the rich? Now-a-days silk-stuffs, exquisitely tasteful and beautiful, can be purchased for a small sum of money, and are worn by hundreds of thousands of the classes whose garments were formerly made of coarse wool or hemp. The old man I speak of was Jacquard, and he was one of the great causes of this diffusion of enjoyment. As I happened to be near the place of his abode, I determined to visit him, and did so, accompanied by several friends.

It was a sunshiny day, I remember, and we had a delightful walk along the margin of the rapid Rhone, a river renowned in history, and whose banks are still crowded with the ruins of past time, calling to mind the days when every feudal chief was obliged to shut himself up in high and embattled towers, built often upon dangerous crags, in order to be secure from the attacks of some neighboring lord. The petty sovereigns and the petty feuds have passed away together. Every thing now bears the face of security, of industry, of peace. Talking of the delightful contrast, and hoping that nations would one day harmonize, as the once contending peasantry of the Rhone *now* harmonize, we reached old Jacquard's abode.

He welcomed us with heartiness. "But come forth into my vineyard," he said; "let us get among the grapes and the sunshine:" so he led the way with a tottering step. "Hither, hither," he called out: "come with me to to the arbor." We followed

him there. "Let me sit in the centre, and let me tell you how glad I am to see you, my friends!" We sat down around him; the clematis was blended with the vine, and together they made the roof and the walls of the quiet retreat, where every day the venerable old man was used to sit, and to recall the events of his much checkered life. Some of those events you shall hear as he himself related them, and you will see what perseverance—virtuous perseverance—is, and what virtuous perseverance can do.

I told Jacquard that I was an Englishman, and as he had been one of the benefactors of my country, I was come to thank him. "How proud I am," said he, "to be visited by an Englishman! If I have ever done any good, I owe the very first suggestion to England. It was an English newspaper that led me to occupy my thoughts with mechanical improvements. But for that, perhaps, I should still have been a poor strawhat maker in an obscure street at Lyons, instead of the happy man you see me, honored by my native town, recompensed by the government (pointing to the red ribband which he wore at his button-hole,) and pensioned by the state." "But how," I inquired, "did you owe to England your first success?" "It was," he answered, "during the peace of Amiens, and we were accustomed to meet, in order to talk politics, at a friend's house on the quay. It was there a translated extract from an English newspaper met my eye, stating that a premium was offered by a society in London to any one who would apply machinery to the manufacture of nets. I meditated long upon the matter, and, after many attempts, I made a machine by which nets could be produced. It was the first of my mechanical experiments, and I will tell you, if you have the patience and the desire to hear me, how that trifling affair was the beginning of my good fortune and my fame." Nothing, we assured him, could gratify us more than to continue his history. "Well, then," said he, "I contrived a machine and made a net by it, and thought no more of the matter. I carried the net about in my pocket, and one day, meeting with a friend who had heard the paragraph of the English paper read, I threw it to him, saying, "There is the difficulty got over, and the net made!" And the matter passed out of my mind. I had persevered until I had succeeded, and there was an end of it. Some time afterwards, I was much surprised at getting an order from the Prefect to appear at the prefectal palace. I went, and the Prefect said he had only lately heard of my proficiency in the mechanical arts. It was a great mystery to me; I really did not comprehend his meaning, and I stammered out a sort of an apology for not understanding him. My net and the machine that made it had gone quite out of my head. The Prefect expressed surprise that I should

deny my own abilities, but at last he produced the very net that I had made, and which to me had seemed a very trifling affair, as it was in reality. 'I have orders from the Emperor to send the machine to Paris,' said the Prefect. 'From the Emperor! That's strange indeed; but you must give me time to make it.' So I set about it, and in a few weeks I completed it, and trudged away with my machine, and a half-manufactured net in it, to the Prefect. He was very impatient to see it work, so I bade him count the number of loops, and then strike the bar with his foot; he did so, and another loop was added to the number. Great was the delight that he expressed, and he told me that no doubt I should hear from him again. I heard from him again, in truth, very soon, and in a way that perplexed me not a little; for his first greeting was, 'You must go to Paris, M. Jacquard, by his majesty's orders.' 'To Paris, sir! how can that be? What have I done? How can I leave my affairs here?' 'Not only must you go to Paris, but you must go to-day—you must go immediately!' These were not times in which there was any resisting the orders of authority; so I said, 'If it must be so, it must; I will go home and pack up my baggage, and I shall be ready to obey your commands.' 'No! M. Jacquard!' said the Prefect, 'you cannot go home; a carriage is waiting to take you to Paris.' 'Not go home! Not say adieu to my wife! Not make up my luggage for a journey of 150 leagues!' 'I have orders,' said the Prefect, 'to despatch you instantly; you may send to your wife; you may tell her to give to my messenger any thing you desire to take—I will provide you with money; but there must be no delay.' There was no arguing about the matter, so I sent to my wife, got a small bundle of clothes, jumped into the carriage, and away! away! we were off, full gallop towards Paris! When we reached the first station, I opened the door, and I found myself stopped by a gendarme, who said to me, 'Sir, if you please, you are not to go out of my sight.' I found I was a prisoner, and escorted by military force to the capital; things were so managed at that time; there was, however, no use in complaining; so I made the best of my fate, and submitted in good humor.

"I reached Paris for the first time in my life, and strange was my introduction there. I was escorted to the Conservatory; and whom should I see there but Napoleon and Carnot! Carnot said to me suddenly, 'Are you the man that can do what Almighty God cannot do?—*tie a knot in a stretched string?*' I was overwhelmed with the presence of the Emperor and the abruptness of his minister, and knew not what to answer. But Napoleon spoke very condescendingly to me about my discovery; told me he would protect me, and urged me to go on with my mechanical pursuits. Ma-

terials were brought me, and I was directed to make a net-producing machine in the Conservatory, which I did At that time a superb shawl was being woven for the Empress Josephine, and for its production they were employing a very costly and complicated loom; a loom upon which more than twenty thousand francs had been expended. It appeared to me that the same effect might be produced by a less perplexing machinery, and I recollected having seen a model by Vaucauson, in which I thought a principle was developed which I could apply to the desired purpose. Long thought and perseverance enabled me to produce the mechanism that bears my name. When I had succeeded, the Emperor conferred this decoration upon me, and granted me a pension of a thousand crowns. But on returning to Lyons, far different was my destiny. When I endeavored to introduce my machine, the workmen broke out into open revolt. I was every where denounced as the enemy of the people, as the man who had been scheming the destruction of their trade, and the starvation of themselves and their families. Three plots were laid to *assassinate* me, and twice I had great difficulty in escaping with my life. So strong was the tide of prejudice and indignation, that my machine was ordered to be openly destroyed by the public authorities. It was broken to pieces in the great square of the city. The iron was sold for old iron, the wood for fire-wood. Think what a shipwreck of all my hopes!

"I did not quite lose courage. The successful competition of foreigners, and the consequent decline of trade in France, led some intelligent manufacturers, a few years after, to think of the man whose discovery might perhaps bring some relief to that depression under which they labored. They found strength of mind to make another experiment. It succeeded. Silks of greater beauty were introduced, at a lower cost. There was a dawn of prosperity, and it has continued to shine. Of that machine which had been devoted to ignominy and destruction, I have now seen thousands introduced, and there is now scarcely any man so blind or so ignorant as not to acknowledge that its introduction has been a great blessing. It has given labor to tens of thousands, and I have had a complete recompense for all I have gone through."

We talked of these and other matters till the shades of coming twilight bade us depart. The happy old man is still in my memory; a striking instance of virtuous perseverance, crowned with fit reward.

Manufacturing Establishments.

We have seen that the application of the *Division of Labor* tends to produce cheaper articles; that it thus increases the demand; and gradually, by the effect of competition, or by the hope of increased gain, that it causes large capitals to be embarked in extensive factories. Let us now examine the influence of this accumulation of capital directed to one object. In the first place, it enables the most important principle on which the advantages of the division of labor depends, to be carried almost to its extreme limits: not merely is the precise amount of skill purchased which is necessary for the execution of each process, but throughout every stage—from that in which the raw material is procured, to that by which the finished produce is conveyed into the hands of the consumer—the same economy of skill prevails. The quantity of work produced by a given number of people is greatly augmented by such an extended arrangement; and the result is necessarily a great reduction in the cost of the article which is brought to market.

Amongst the causes which tend to the cheap production of any article, and which are connected with the employment of additional capital, may be mentioned the care which is taken to prevent the absolute waste of any part of the raw material. An attention to this circumstance sometimes causes the union of two trades in one factory, which otherwise might have been separated.

An enumeration of the arts to which the horns of cattle are applicable, will furnish a striking example of this kind of economy. The tanner who has purchased the raw hides, separates the horns, and sells them to the makers of combs and lanterns. The horn consists of two parts, an outward horny case, and an inward conical substance, somewhat intermediate between indurated hair and bone. The first process consists in separating these two parts, by means of a blow against a block of wood. The horny exterior is then cut into three portions with a frame-saw.

1. The lowest of these, next the root of the horn, after undergoing several processes, by which it is flattened, is made into combs. 2. The middle of the horn, after being flattened by heat, and having its transparency improved by oil, is split into thin layers, and forms a substitute for glass, in lanterns of the commonest kind. 3. The tip of the horn is used by the makers of knife-handles, and of the tops of whips, and for other similar purposes. 4. The interior, or core of the horn, is boiled down in water. A large quantity of fat rises to the surface; this is put aside, and sold to the makers of yellow soap. 5. The liquid itself is used as a kind of glue, and is purchased by cloth-dressers for stiffening. 6.

The insoluble substance, which remains behind, is then sent to the mill, and, being ground down, is sold to the farmers for manure.
7. Besides these various purposes to which the different parts of the horn are applied, the clippings which arise in comb-making are sold to the farmer for manure. In the first year after they are spread over the soil they have comparatively little effect, but during the next four or five their efficiency is considerable. The shavings which form the refuse of the lantern-maker, are of a much thinner texture: some of them are cut into various figures, and painted, and used as toys; for being hygrometric, they curl up when placed on the palm of a warm hand. But the greater part of these shavings also are sold for manure, and from their extremely thin and divided form, the full effect is produced upon the first crop.

In many of the large establishments of our manufacturing districts, substances are employed which are the produce of remote countries, and which are, in several instances, almost peculiar to a few situations. The discovery of any new locality, where such articles exist in abundance, is a matter of great importance to any establishment which consumes them in large quantities; and it has been found, in some instances, that the expense of sending persons to great distances, purposely to discover and to collect such produce, has been amply repaid. Thus it has happened, that the snowy mountains of Sweden and Norway, as well as the warmer hills of Corsica, have been almost stripped of one of their vegetable productions, by agents sent expressly from one of our largest establishments for the dyeing of calicoes. Owing to the same command of capital, and to the scale upon which the operations of large factories are carried on, their returns admit of the expense of sending out agents to examine into the wants and tastes of distant countries, as well as of trying experiments, which, although profitable to them, would be ruinous to smaller establishments possessing more limited resources.

When capital has been invested in machinery, and in buildings for its accommodation, and when the inhabitants of the neighborhood have acquired a knowledge of the modes of working at the machines, reasons of considerable weight are required to cause their removal. Such changes of position do, however, occur; and they have been alluded to by the committee on the fluctuation of manufacturers' employment, as one of the causes interfering most materially with a uniform rate of wages; it is therefore of particular importance to the workmen to be acquainted with the real causes which have driven manufactures from their ancient seats.

"The migration or change of place of any manufacture has sometimes arisen from improvements of machinery not applicable

to the spot where such manufacture was carried on, as appears to have been the case with the woollen manufacture, which has in great measure migrated from Essex, Suffolk, and other southern counties, to the northern districts, where coal for the use of the steam engine is much cheaper. But this change has, in some instances, been caused or accelerated by the conduct of the workmen, in refusing a reasonable reduction of wages, or opposing the introduction of some kind of improved machinery or process; so that, during the dispute, another spot has in great measure supplied their place in the market. Any violence used by the workmen against the property of their employers, and any unreasonable combination on their part, is almost sure thus to be injurious to themselves."

These removals become of serious consequence when the factories have been long established, because a population commensurate with their wants invariably grows up around them. The combinations in Nottinghamshire, of persons under the name of Luddites, drove a great number of lace-frames from that district, and caused establishments to be formed in Devonshire. We ought also to observe, that the effect of driving any establishment into a new district, where similar works have not previously existed, is not merely to place it out of the reach of such combinations, but, after a few years, the example of its success will most probably induce our capitalists in the new district to engage in the same manufacture: and thus, although one establishment only should be driven away, the workmen, through whose combination its removal is effected, will not merely suffer by the loss of that portion of demand for their labor which the factory caused; but the value of that labor will itself be reduced by the competition of a new field of production.

It is of great importance that the more intelligent amongst the class of workmen should examine into the correctness of these views; because, without having their attention directed to them, the whole class may, in some instances, be led by designing persons to pursue a course, which, although plausible in appearance, is in reality at variance with their own best interests.—*Babbage's Economy of Man.*

The Mechanical Fiddler.

One of the most extraordinary and the best attested instances of enthusiasm, existing in conjunction with perseverance, is related of the founder of the F—— family. This man, who was a fiddler living near Stourbridge, was often witness of the immense labor

and loss of time caused by dividing the rods of iron necessary in the process of making nails. The discovery of the process called splitting, in works called splitting-mills, was first made in Sweden; and the consequences of this advance in art were most disastrous to the manufacturers of iron about Stourbridge. F—— the fiddler was shortly missed from his accustomed rounds, and was not again seen for many years. He had mentally resolved to ascertain by what means the process of splitting bars of iron was accomplished; and without communicating his intention to a single human being, he proceeded to Hull, and, without funds, worked his passage to the Swedish iron port. Arrived in Sweden, he begged and *fiddled* his way to the iron foundries, where he, after a time, became a universal favorite with the workmen; and from the apparent entire absence of intelligence, or any thing like ultimate object, he was received into the works, to every part of which he had access. He took the advantage thus offered, and, having stored his memory with observations, and all the combinations, he disappeared from amongst his kind friends as he had appeared, no one knew whence or whither.

On his return to England, he communicated his voyage and its result to Mr. Knight and another person in the neighborhood, with whom he was associated, and by whom the necessary buildings were erected, and machinery provided. When at length every thing was prepared, it was found that the machinery would not act; at all events it did not answer the sole end of its erection—it would not split the bar of iron. F—— disappeared again; it was concluded that shame and mortification at his failure had driven him away forever. Not so; again, though somewhat more speedily, he found his way to the Swedish iron-works, where he was received most joyfully, and, to make sure of their fiddler, he was lodged in the splitting-mill itself. Here was the very aim and end of his life attained, beyond his utmost hope. He examined the works, and very soon discovered the cause of his failure. He now made drawings, or rude tracings; and having abided an ample time to verify his observations, and to impress them clearly and vividly on his mind, he made his way to the port, and once more returned to England. This time he was completely successful, and by the results of his experience enriched himself and greatly benefited his countrymen, who doubtless came to the conclusion that *he* at least *fiddled to some purpose.*

Corn Mills in Ancient Times.

Till about fifty years before the commencement of the Christian era, the ancients had no large mills forced round by water, but ground their corn in small mills of one stone rolling rapidly round upon another, and impelled by the hands of women-servants or slaves. The stones used for that purpose were circular, portable, nicely wrought, and adapted for turning; the upper one being the smaller of the two, with an iron or wooden handle fixed into its edge; the lower being larger, and probably harder—at least if we may infer from an expression in the book of Job, "hard as a piece of the nether millstone." An excellent quarry in the neighborhood of Babylon (we are informed by Xenophon) supplied all the countries of the East with such millstones.

That women, or maid-servants, generally performed this piece of domestic labor, we are assured by the very first mention made of grinding with mills, that in Exodus, (xi. 5,) "All the first-born in the land of Egypt shall die, from the first-born of Pharaoh that sitteth upon the throne, even unto the first-born of the maid-servant that is behind the mill;" in which passage, from the contrasted states of dignity and meanness, it is plain, that, in Egypt at least, the drudgery of grinding was deemed the lowest possible. Two women were generally employed; they sat fronting each other, with the millstone between them, which was kept whirling by alternate impulsions of the hand. Slaves taken in war were frequently doomed to undergo this tedious penance; Samson "did grind in the prison-house of the Philistines;" the Hebrews, in their Babylonish captivity, were subjected to its degradation; "they took our young men to grind," says Jeremiah in his Lamentations; and Isaiah, in his prophetic declaration to Babylon of her impending state of captivity, bids her, as a proper badge of her servile subjection, "take millstones and grind meal." The piece of a millstone whereby Abimelech was slain, when he was attacking the tower of Thebez, was cast upon his head by a "certain woman," whom it befitted to wield as a weapon, the humble utensil of her daily occupation.

Portable millstones of this description must have been brought by the children of Israel from Egypt, and carried with them all the way through the wilderness, as we read in Numbers, (xi. 8,) that "the people ground the manna in mills." As by the laws of Athens no creditor was allowed to distrain the plough and other simple and necessary utensils of rustic labor, so by the laws of Moses, (Deut. xxiv. 6,) it was permitted to no man "to take the nether or the upper millstone to pledge"—in other words, to take

them by distraint in lieu of any debt. The morning, before or at sunrise, was the time allotted in the domestic arrangement for grinding for the family as much flour as was needful for the consumption of the day.

An interesting particular connected with the practice of nocturnal grinding, may be quoted from the military history of Julian. His forces, when besieging some strong place on the Tigris, had wrought a deep mine under the walls and buildings to the very centre of the city, when his soldiers, on digging the earth upwards to the surface, found themselves after midnight in the middle of the house of a poor woman, who was busily employed in grinding corn for flour-bread, and who, doubtless, was not a little astonished at the emersion into her solitary chamber of such extraordinary visitants.

The operation of grinding by the females was always accompanied, as it still is in the East, with melodious and shrill-trilled ditties, sung in chorus, which sounded strong enough to be heard out of doors throughout all the lanes and streets; the pleasant jolity of which, associated as it was with the just apparent brightness of dawn, and announcing the approaching activity of village or city population just awaking to their daily labor, gave to this simple domestic operation a peculiar character of happiness, peaceful industry, and tranquillity. The Hebrew writers, accordingly, always connect the sound of the morning mill with prosperity and repose, coupling it, in its degree of vivacity, with "the voice of harpers and musicians;" its cessation they associate with the presence of melancholy, trouble, and adversity. Thus, when the wise man wishes to describe the dreary melancholy of old age, he expresses it by the "sound of the grinding" being "low." "I will take away the sound of the millstone," says Jeremiah, to express utter desolation. We are informed by travellers that such lively chants are still sung by females in Persia and Africa when engaged in grinding. The heart of Mungo Park, in the Afric desert, was softened and reminded of his home by the chant of the women grinding. The Grecian women, also, had a ditty of this kind, called the Song of the Mill. It began, "Grind, mill, grind; even Pittacus king of Mitylene doth grind." For it seems that Pittacus, king, or tyrant, as he was called, of Mitylene, and reckoned also one of the seven wise men of Greece, had been accustomed, in moments of unoccupied languor, to resort for amusement to the grinding-mill, that being, as he called it, his best gymnasium, or pleasantest exercise in smallest space. As sometimes for health, so sometimes also for obtaining an honest livelihood, was grinding resorted to by persons above the common order. There is a story

told of the two philosophers Menedemus and Asclepiades, who, when young men, and students of wisdom under one of the Athenian masters, were enabled to maintain a respectable personal appearance by grinding every night at the mill for two drachmæ, or about 1s. 4d. a night; on hearing which signal proof of industry, the Areopagites, in admiration of their love of wisdom and frugality, presented them with an honorary donation of two hundred drachmæ, to support them during their time of study.

The Romans seem to have invented a larger class of mills, driven by mules, asses, or oxen, (called molæ jumentariæ,) and to have introduced them during the course of their conquests in the East. The stones employed in these mills were of a larger size, and much more operose in their revolution, and effective in their labor. Allusion is made to one of these larger millstones in the passage of the Gospel, (Luke xvii. 2,) where it is said, "it were better that a millstone were hanged about his neck," the larger millstone impelled by asses being there understood in the original; it is to be regretted that the emphasis given to the sentiment by the distinctive word implying the larger stone, is lost in our translation.

The first corn-mill driven by water was invented and set up by Mithridates, king of Cappadocia, the most talented, studious, and ingenious prince of any age or country. It was set up in the neighborhood of his capital or palace, about seventy years before the commencement of the Christian era. It was probably from this favorable circumstance of the invention of the water-mill, and the facility thereby afforded to the Cappadocian people for making cheap, good, and abundant flour, that the Cappadocian bakers obtained high celebrity, and were much in demand for two or three centuries posterior to the invention of mills, throughout all the Roman world. Coincident with the era of the inventor, as mentioned by Strabo, is the date of the Greek epigram on water-mills by Antipater, a poet of Syria or Asia Minor, who is supposed to have lived sixty or eighty years before Christ. This epigram may be thus translated:—

> Ye maids, who toil'd so faithful at the mill,
> Now cease from work, and from these toils be still;
> Sleep now till dawn, and let the birds with glee
> Sing to the ruddy morn on bush and tree;
> For what your hands performed so long, so true,
> Ceres has charg'd the water-nymphs to do;
> They come, the limpid sisters, to her call,
> And on the wheel with dashing fury fall;
> Impel the axle with a whirling sound,
> And make the massy millstone reel around,
> And bring the floury heaps luxuriant to the ground.

The greater convenience and expedition in working of these water-mills soon made them be spread over the world. In about twenty or thirty years after their invention, one was set up on the Tiber. They must have been not uncommon in Italy in the age of Vitruvius, for he gives a description of them. Yet it is rather surprising that Pliny, whose eye nothing of art or nature escapes, has taken no notice of them. In the age of Theodosius, (about 380 A. D.,) the public corn-mills of the city of Rome seem to have been wrought principally or altogether by slaves. According to an historian, these corn-mills were all placed in the subterranean apartments or cellars of an immense pile of buildings used by the Roman bakers as a public bakehouse. He tells a strange story of this Roman pistrinum. It was built, it seems, on an immense scale, with grinding dungeons below, and shops or taverns along its front and sides, where were sold the loaves, and wherein were at the same time exhibited other tavern temptations to seduce the simple ones and the strangers. Into these trap-taverns people went without suspicion; but no sooner were some of them wheedled in, than, by means of some mechanical pitfalls made in the floor, they were precipitated into the grinding-vault, and found themselves irrecoverably caught and imprisoned. There they were compelled to work as drudges of the mill, their friends all the while believing them dead. At last the insidious bakehouse was exposed and destroyed by a soldier of Theodosius. He, too, was plunged into the subterranean mill-house, but fortunately having his sword at his side, he drew it, and by the terror of his menaces, and his layings-about, he forced the people to let him go. The insidious work-house was exposed, and, by the order of the emperor, demolished to its foundations. At a later period, Rome was supplied with meal from mills placed upon boats on the Tiber, the rush of the water driving the wheels.

Mills on a large scale have been for ages established in all European and other countries in which the arts have been improved. In some of the remote parts of the British islands, however, the practice of bruising corn in a mortar, or of grinding it in a small hand-mill, is not yet entirely disused. In the Highlands of Scotland, these rudely fashioned hand-mills are called querns; and the primeval practice of singing while working at them is still kept up. Pennant, in his Tour through Scotland in 1769, gives drawings of the Highland querns. Mr. Robert Jamieson, in a work entitled "Popular Ballads and Songs," of which he was editor, relates the following interesting anecdote, illustrative of the condition of life in which the quern is still, or was lately, in use:—

"On a very hot day in the beginning of autumn, the author,

when a stripling, was travelling afoot over the mountains of Lochaber, from Fort Augustus to Inverness; and when he came to the house where he was to have breakfasted, there was no person at home, nor was there any place where refreshment was to be had nearer than Duris, which is eighteen miles from Fort Augustus. With this disagreeable prospect, he proceeded about three miles farther, and turned aside to the first cottage he saw, where he found a hale-looking, lively, tidy, little, middle-aged woman, spinning wool, with a pot on the fire, and some greens ready to be put into it. She understood no English, and his Gaelic was then by no means good, though he spoke it well enough to be intelligible. She informed him that she had nothing in the house that could be eaten, except cheese, a little sour cream, and some whiskey. On being asked, rather sharply, how she could dress the greens without meal, she good-humoredly told him that there was plenty of meal in the croft, pointing to some unreaped barley that stood dead-ripe and dry before the door; and if he could wait half an hour, he should have brose and butter, bread and cheese, bread and milk, or any thing else that he chose. To this he most readily assented, as well on account of the singularity of the proposal, as of the necessity of the time; and the good dame set with all possible expedition about her arduous undertaking. She first of all brought him some cream in a bottle, telling him, 'He that will not work, neither shall he eat;' if he wished for butter, he must shake that bottle with all his might, and sing to it like a mavis all the time; for unless he sang to it, no butter would come. She then went to the croft, cut down some barley, burnt the straw to dry the grain, rubbed the grain between her hands, and threw it up before the wind to separate it from the husks; ground it upon a quern, sifted it, made a bannock of the meal, set it up to bake before the fire; lastly, went to milk her cow, that was reposing during the heat of the day, and eating some outside cabbage leaves 'ayont the hallan.' She sang like a lark the whole time, varying the strain according to the employment to which it was adapted. In the mean while, a hen cackled under the eaves of the cottage; two new-laid eggs were immediately plunged into the boiling pot, and in less than half an hour, the poor, starving, faint, and way-worn minstrel, with wonder and delight sat down to a repast, that, under such circumstances, would have been a feast for a prince."

The Obelisk of Luxor.

We fancy there are few of our readers but have read descriptions and seen drawings or prints of the two remarkable obelisks called Cleopatra's Needles, near Alexandria, on the coast of Egypt. Of these only one is erect; the other has been for many years prostrate and half buried in sand.

Among the treasures of antiquity found in the interior of Egypt, and particularly in the Thebaid, were, till very lately, two granite columns of precisely the same character as Cleopatra's Needles. Of these, one remains on the desolate spot; the other, with great labor and expense, has been transported to the flourishing capital of France.

When the French army, in their attempt on Egypt, penetrated as far as Thebes, they were, almost to a man, overpowered by the majesty of the ancient monuments they saw before them; and Bonaparte is then said to have conceived the idea of removing at least one of the obelisks to Paris. But reverses and defeat followed. The French were forced to abandon Egypt; and the English remaining masters of the seas, effectually prevented any such importation into France.

The project of Bonaparte had the sort of classical precedent he so much admired. Roman conquerors and Roman emperors had successively enriched the capital of the world with the monuments of subdued nations, and with the spoils of art from Sicily, Greece, and Egypt. Among these, the Emperor Augustus ordered two Egyptian obelisks, also of the same character as Cleopatra's Needles, to be brought to Rome. To this end an immense vessel of a peculiar construction was built; and when, after a tedious and difficult voyage, it reached the Tiber with its freight, one of the columns was placed in the Grand Circus, and the other in the Campus Martius, at Rome. Caligula adorned Rome with a third Egyptian obelisk, obtained in the same manner.

The Emperor Constantine, still more ambitious of these costly foreign ornaments, resolved to decorate his new-founded capital of Constantinople with the largest of all the obelisks that stood on the ruins of Thebes. He succeeded in having it conveyed as far as Alexandria; but, dying at the time, its destination was changed, and an enormous raft, managed by 300 rowers, transported the granite obelisk from Alexandria to Rome. The difficulties encountered by the large, flat, awkward vessel do not appear to have occurred during the passage across the Mediterranean, which was, no doubt, effected during the fine, settled summer season, when that sea is often, for weeks together, almost

as calm as a small fresh-water lake; but they presented themselves at the passage of the mouth of the Tiber, and in the shallows of that river. When all these obstacles were overcome, it required the labor of thousands of men to set up the obelisk upon its base at Rome.

The Emperor Theodosius, at last, succeeding in bringing an obelisk from Egypt to Constantinople, erected it in the Hippodrome. Though this was of an inferior size, (being rather under than over fifty feet,) it is recorded that it required thirty-two days' labor, and the most complicated contrivances of mechanics to set it upright.

The Constantinopolitan obelisk still stands where it was first erected by the emperor; but those of Rome have been removed by the Popes. In all, there are twelve ancient obelisks erect in the modern city of Rome.

Thirty years after Bonaparte's first conception of the idea, the French government, then under Charles X., having obtained the consent of the pasha of Egypt, determined that one of the obelisks of Luxor should be brought to Paris. "The difficulties of doing this," says M. Delaborde, "were great. In the first place it was necessary to build a vessel which should be large enough to contain the monument,—deep enough to stand the sea,—and, at the same time, draw so little water as to be able to ascend and descend such rivers as the Nile and the Seine."

In the month of February, 1831, when the crown of France had passed into the hands of Louis Philippe, a vessel, built as nearly as could be on the necessary principles, was finished and equipped at Toulon. This vessel, which for the sake of lightness was chiefly made of fir and other white wood, was named the "Louxor." The crew consisted of 120 seamen, under the command of Lieutenant Verninac of the French royal navy; and there went, besides, sixteen mechanics of different professions, and a master to direct the works, under the superintendence of M. Lebas, formerly a pupil of the Polytechnic School, and now a naval engineer.

M. J. P. Angelina accompanied the expedition in quality of surgeon-major; and to a volume which this gentleman has recently published at Paris we are indebted for an account of its proceedings.

On the 15th of April, 1831, (which we should have thought two months too early in the season,) the "Louxor" sailed from Toulon. Some rather violent winds and heavy seas proved that a vessel so built was not very seaworthy, and appear to have somewhat frightened the "Chirurgien-Major;" but they arrived without any

serious accident in the port of Alexandria on the 3d of May. After staying forty-two days at Alexandria, the expedition sailed again on the 15th of June for the Rosetta mouth of the Nile, which they entered on the following day, though not without danger from the sand-bank which the river has deposited there. At Rosetta they remained some days; and on the 20th of June, M. Lebas, the engineer, two officers, and a few of the sailors and workmen, leaving the "Louxor" to make her way up the river slowly, embarked in common Nile-boats for Thebes, carrying with them the tools and materials necessary for the removal of the obelisk. On the 7th of July, when the waters of the Nile had risen considerably, the "Louxor" sailed from Rosetta; on the 13th she reached Boulak, the port of Grand Cairo, where she remained until the 19th; and she did not arrive at Thebes until the 14th of August, which was two months after her departure from Alexandria.

The Turks and Arabs were astonished at seeing so large a vessel on the Nile, and frequently predicted she would not accomplish the whole voyage. The difficulties encountered in so doing were, indeed, very serious; in spite of the peculiar build and material, the vessel grounded and struck fast in the sand several times; at other times a contrary wind, joined to the current, which was of course contrary all the way up, obliged them to lie at anchor for days; and the greatest part of the ascent of the river was effected by towing, which exhausting work seems to have been performed, partly by the French sailors, and partly by such Arabs and Fellahs as they could hire for the occasion. An excessive heat rendered this fatigue still more insupportable. Fahrenheit's thermometer marked from 98° to 102° in the shade, and ascended to 144°, and even to 160° in the sun. Several of the sailors were seized with dysentery, and the quantity of sand blown about by the wind, and the glaring reflection of the burning sun, afflicted others with painful ophthalmia. The sand must have been particularly distressing: one day the wind raised it and rolled it onward in such volume as, at intervals, to obscure the light of the sun. After they had felicitated themselves on the fact that the plague was not in the country, they were struck with alarm on the 29th of August, by learning that the cholera morbus had broken out most violently at Cairo. On the 11th of September the same mysterious disease declared itself on the plain of Thebes, with the natives of which the French were obliged to have frequent communications. In a very short time fifteen of the sailors, according to our author, the surgeon, caught the contagion, but every one recovered under his care and skill. At the

same time, however, (panic no doubt increasing the disposition to disease,) no fewer than forty-eight men were laid up with dysentery, which proved fatal to two of them.

In the midst of these calamities and dangers, the French sailors persevered in preparing the operations relative to the object of the expedition. One of the first cares of M. Lebas, the engineer, on his arriving on the plain of Thebes, was to erect, near to the obelisks and not far from the village of Luxor, proper wooden barracks,—sheds and tents to lodge the officers, sailors, and workmen, on shore. He also built an oven to bake them bread, and magazines in which to secure their provisions, and the sails, cables, &c., of the vessel. The now desolate site on which the city of the Hundred Gates, the vast, the populous, and the wealthy Thebes, once stood, offered them no resources, nor a single comfort of civilized life. But French soldiers and sailors are happily, and, we may say, honorably distinguished, by the facility with which they adapt themselves to circumstances, and turn their hands to whatever can add to their comfort and well-being. The sailors on this expedition, during their hours of repose from more severe labors, carefully prepared and dug up pieces of ground for kitchen-gardens. They cultivated bread-melons and water-melons, lettuces, and other vegetables. They even planted some trees, which thrived very well ; and, in short, they made their place of temporary residence a little paradise as compared with the wretched huts and neglected fields of the oppressed natives.

It was the smaller of the two obelisks the French had to remove. But this smaller column of hard, heavy granite was about ninety or a hundred feet in height, and was calculated to weigh upwards of two hundred and forty tons. It stood, moreover, at the distance of about one thousand two hundred feet from the Nile, and the intervening space presented many difficulties.

M. Lebas, the engineer, commenced by making an inclined plane, extending from the base of the obelisk to the edge of the river. This work occupied nearly all the French sailors and about seven hundred Arabs during three months, for they were obliged to cut through two hills of ancient remains and rubbish, to demolish half of the poor villages which lay in their way, and to beat, equalize, and render firm the uneven, loose and crumbling soil. This done, the engineer proceeded to make the ship ready for the reception of the obelisk. The vessel had been left aground by the periodical fall of the waters of the Nile, and matters had been so managed that she lay imbedded in the sand, with her figure-head pointing directly towards the temple and the granite column. The engineer taking care not to touch the keel, sawed off

a transverse and complete section of the front of the ship; in short, he cut away her bows, which were raised, and kept suspended above the place they properly occupied by means of pulleys and some strong spars, which crossed each other above the vessel.

The ship, thus opened, presented in front a large mouth to receive its cargo, which was to reach the very lip of that mouth or opening, by sliding down the inclined plane. When this section of the ship was effected, they took care that she should lie equally on her keel; and where the sand or mud was weak, or had fallen away from the vessel, they supplied proper supports and props to prevent the great weight of the column from breaking her back. The preparations for bringing the obelisk safely down to the ground lasted from the 11th of July to the 31st of October, when it was laid horizontally on its side.

The rose-colored granite of Syene, (the material of these remarkable works of ancient art,) though exceedingly hard, is rather brittle. By coming in contact with other substances, and by being impelled along the inclined plane, the beautiful hieroglyphics sculptured on its surface might have been defaced, and the obelisk might have suffered other injuries. To prevent these, M. Lebas encased it, from its summit to its base, in strong thick wooden sheathings, which were well secured to the column by means of hoops. The western face of this covering, which was that upon which the obelisk was to slide down the inclined plane, was rendered smooth, and was well rubbed with grease to make it run the easier.

The mechanical contrivance to lower the column, which was by far the most critical part of these operations, is described as having been very simple. A cable of immense strength was attached to a strong anchor deeply sunk in the earth, and well secured at some distance from the monument. This cable was carried forward and made fast to the top of the obelisk, and then descending in an acute angle in the rear of the obelisk, the cable was retained in an opposite direction to the anchor by means of an enormous beam of wood, and by a series of pulleys and capstans. The column had been perfectly cleared from the sand and earth round its base, and walls of a certain height erected to keep it in the proper line of descent. Other works at its base prevented the column from sliding backwards in its descent, and a strong bed made of oak, and immediately connected with the inclined plane, was ready to receive it, and pass it to the plane when it reached a certain low angle of declination.

To move so lofty and narrow an object from its centre of gravity was no difficult task,—but then came the moment of intense

anxiety! The whole of the enormous weight bore upon the cable, the cordage, and machinery, which quivered and cracked in all their parts. Their tenacity, however, was equal to the strain, and so ingeniously were the mechanical powers applied, that eight men in the rear of the descending column were sufficient to accelerate or retard its descent. For two minutes the obelisk was suspended at an angle of 30°,—but, finally, it sank majestically and in perfect safety to the bed of the inclined plane.

On the following day the much less difficult task of getting the obelisk on board the ship was performed. It only occupied an hour and a half to drag the column down the inclined plane, and (through the open mouth in front) into the hold of the vessel. The section of the suspended bows was then lowered to the proper place, and readjusted and secured as firmly as ever by the carpenters and other workmen. So nicely was this important part of the ship sliced off, and then put to again, that the mutilation was scarcely perceptible.

The obelisk, as we have seen, was embarked on the 1st of November, 1831, but it was not until the 18th of August, 1832, that the annual rise of the Nile afforded sufficient water to float their long-stranded ship. At last, however, to their infinite joy, they were ordered to prepare every thing for the voyage homewards. As soon as this was done, sixty Arabs were engaged to assist in getting them down the river, (a distance of one hundred and eighty leagues,) and the Louxor set sail.

After thirty-six days of painful navigation, but without meeting with any serious accident, they reached Rosetta; and there they were obliged to stop, because the sand-bank off that mouth of the Nile had accumulated to such a degree, that, with its present cargo, the vessel could not clear it. Fortunately, however, on the 30th of December, a violent hurricane dissipated part of this sand-bank; and, on the 1st of January, 1833, at ten o'clock in the morning, the Louxor shot safely out of the Nile, and at nine o'clock on the following morning came to a secure anchorage in the old harbor of Alexandria.

Here they awaited the return of the fine season for navigating the Mediterranean; and the Sphynx (a French man-of-war) taking the Louxor in tow, they sailed from Alexandria on the 1st of April. On the 2d, a storm commenced, which kept the Louxor in imminent danger for two whole days. On the 6th, this storm abated; but the wind continued contrary, and soon announced a fresh tempest. They had just time to run for shelter into the bay of Marmara when the storm became more furious than ever.

On the 13th of April they again weighed anchor, and shaped their course for Malta; but a violent contrary wind drove them back as far as the Greek island of Milo, where they were detained two days. Sailing, however, on the 17th, they reached Navarino on the 18th, and the port of Corfu, where, they say, they were kindly received by Lord Nugent and the British, on the 23d of April. Between Corfu and Cape Spartivento, heavy seas and high winds caused the Louxor to labor and strain exceedingly. As soon, however, as they reached the coast of Italy, the sea became calm, and a light breeze carried them forward, at the rate of four knots an hour, to Toulon, where they anchored during the evening of the 11th of May.

They had now reached the port whence they had departed, but their voyage was not yet finished. There is no carriage by water, or by any other commodious means, for so heavy and cumbrous a mass as an Egyptian obelisk, from Toulon to Paris, (a distance of above four hundred and fifty miles.) To meet this difficulty they must descend the rest of the Mediterranean, pass nearly the whole of the southern coast of France, and all the south of Spain—sail through the Straits of Gibraltar, and traverse part of the Atlantic, as far as the mouth of the Seine, which river affords a communication between the French capital and the ocean.

Accordingly, on the 22d of June, they sailed from Toulon, the Louxor being again taken in tow by the Sphynx man-of-war; and, after experiencing some stormy weather, finally reached Cherbourg on the 5th of August, 1833. The whole distance performed in this voyage was upwards of fourteen hundred leagues.

As the royal family of France was expected at Cherbourg by the 31st of August, the authorities detained the Louxor there On the 2d of September, King Louis Philippe paid a visit to the vessel, and warmly expressed his satisfaction to the officers and crew. He was the first to inform M. Verninac, the commander, that he was promoted to the rank of captain of a sloop-of-war. On the following day, the king distributed decorations of the legion of honor to the officers, and entertained them at dinner.

The Louxor, again towed by the Sphynx, left Cherbourg on the 12th of September, and safely reached Havre de Grace, at the mouth of the Seine. Here her old companion, the Sphynx, which drew too much water to be able to ascend the river, left her, and she was taken in tow by the Heva steamboat. To conclude with the words of our author: "At six o'clock (on the 13th) our vessel left the sea for ever, and entered the Seine. By noon we had cleared all the banks and impediments of the lower part of the river; and, on the 14th of September, at noon, we arrived at

Rouen, where the Louxor was made fast before the quay d'Harcourt. Here we must remain until the autumnal rains raise the waters of the Seine, and permit us to transport to Paris this pyramid,—the object of our expedition." This event has since happened, and the column safely erected on its pedestal.

American Steamers.

The following extract from a late London work, "Stevenson's Engineering in North America," may not be uninteresting to most of our readers:—

"The steam navigation of the United States is one of the most interesting subjects connected with the history of North America; and it is strange that hitherto we should have received so little information regarding it, especially as there is no class of works, in that comparatively new and still rising country, which bear stronger marks of long-continued exertion, successfully directed to the perfection of its object, than are presented by many of the steamboats which now navigate its rivers, bays, and lakes.

"It would be improper to compare the present state of steam navigation in America with that of this country, for the nature of things has established a very important distinction between them. By far the greater number of the American steamboats ply on the smooth surfaces of rivers, sheltered bays, or arms of the sea, exposed neither to waves nor to wind; whereas most of the steamboats in this country go out to sea, where they encounter as bad weather and as heavy waves as ordinary sailing vessels. The consequence is, that in America a much more slender built, and a more delicate mould, give the requisite strength to their vessels, and thus a much greater speed, which essentially depends upon these two qualities, is generally obtained. In America, the position of the machinery and of the cabins, which are raised above the deck of the vessels, admits of powerful engines, with an enormous length of stroke being employed to propel them; but this arrangement would be wholly inapplicable to the vessels navigating our coasts, at least to the extent to which it has been carried in America.

"But perhaps the strongest proof that the American vessels are very differently circumstanced from those of Europe, and therefore admit of a construction more favorable for the attainment of great speed, is the fact that they are not generally, as in Europe, navigated by persons possessed of a knowledge of seamanship. In this country steam navigation produces hardy seamen; and

British steamers being exposed to the open sea in all weathers, are furnished with masts and sails, and must be worked by persons who, in the event of any accident happening to the machinery, are capable of sailing the vessel, and who must therefore be experienced seamen. The case is very different in America, where, with the exception of the vessels navigating the lakes, and one or two of those which ply on the eastern coast, there is not a steamer in the country which has either masts or sails, or is commanded by a professional seaman. These facts forcibly show the different state of steam navigation in America,—a state very favorable for the attainment of great speed, and a high degree of perfection in the locomotive art.

"The early introduction of steam navigation into the country, and the rapid increase which has since taken place in the number of steamboats, have afforded an extensive field for the prosecution of valuable inquiries on this interesting subject; and the builders of steamboats, by availing themselves of the opportunities held out to them, have been enabled to make constant accessions to their practical knowledge, which have gradually produced important improvements in the construction and action of their vessels. But on minutely examining the most approved American steamers, I found it impossible to trace any *general* principles which seem to have served as guides for their construction. Every American steamboat builder holds opinions of his own, which are generally founded, not on theoretical principles, but on deductions drawn from a close examination of the practical effects of the different arrangements and proportions adopted in the construction of different steamboats, and these opinions never fail to influence, in a greater or less degree, the built of his vessel, and the proportions which her several parts are made to bear to each other.

"The voyage between Albany and New York is now generally performed in ten hours, exclusive of the time lost in making stoppages, being at the astonishing rate of fifteen miles per hour. They have effected this great increase of speed by constantly making experiments on the form and proportions of their engines and vessels,—in short, by a persevering system of *trial and error*, which is still going forward; and the natural consequence is, that, even at this day, no two steamboats are alike, and few of them have attained the age of six months without undergoing some material alterations.

"These observations apply more particularly to the steamers navigating the eastern waters of the United States, where the great number of steamboat builders, and the rapid increase of trade, have produced a competition which has led to the construction of

a class of vessels unequalled in point of speed by those of any other quarter of the globe. The original construction of most of these vessels has, as already stated, been materially changed. The breadth of beam and the length of keel have in some vessels been increased, and in others they have been diminished. This mode of procedure may seem rather paradoxical; but in America it is no uncommon thing to alter steamboats by cutting them through the middle, and either increasing or diminishing their dimensions as the occasion may require. It is only a short time since many of the steamboats were furnished with false bows, by which the length of the deck and the rake of the cutwaters were greatly increased. On some vessels these bows still remain; from others they have been removed,—subsequent experiments having led to the conclusion, that a perpendicular bow without any rake is best adapted for a fast-sailing boat. When I visited the United States in 1837, the 'Swallow' held the reputation of being one of the two swiftest steamers which have ever navigated the American waters, and this vessel had received an addition of twenty-four feet to her original length, besides having been otherwise considerably changed Before these alterations were made on her, she was considered, as regards speed, to be an inferior vessel.

"The inferences to be drawn from these facts are, that the great experiment for the improvement of steam navigation, in which the Americans may be said to have been engaged for the last thirty years, is not completed, and the speed at which they have succeeded in propelling their steam-vessels may yet be increased; and also that, in the construction of their vessels, they have been governed by experience and practice alone, without attempting to introduce theoretical principles, in the application of which, to the practice of propelling vessels, by the action of paddle-wheels on the water, numerous difficulties have hitherto been experienced.

"There are local circumstances, connected with the nature of the trade in which the steamboats are engaged, and the waters which they are intended to navigate, that have given rise to the employment of three distinct classes of vessels in American steam navigation, all of which I had an opportunity of sailing in and particularly examining.

"These steamboats may be ranged under the following classification:—First, those navigating the Eastern waters. This class includes all the vessels plying on the river Hudson, Long Island Sound, Chesapeake and Delaware Bays, and all those which run to and from Boston, New York, Philadelphia, Baltimore, Charleston, Norfolk, and the other ports on the eastern coast of the country, or what the Americans call the sea-board. Second, those

navigating the Western waters, including all the steamers employed on the river Mississippi and its numerous tributaries, including the Missouri and Ohio. Third, the steamers engaged in the Lake navigation. These classes of vessels vary very much in their construction, which has been modified to suit the respective services for which they are intended.

"The general characteristics by which the Eastern water boats are distinguished, are, a small draught of water, great speed, and the use of condensing engines of large dimensions, having a great length of stroke. On the Western waters, on the other hand, the vessels have a greater draught of water and less speed, and are propelled by high-pressure engines of small size, worked by steam of great elasticity. The steamers on the Lakes, again, have a very strong built and a large draught of water, possessing in a greater degree the character of *sea*-boats than any of those belonging to the other two classes. They also differ in having masts and sails, with which the others are not provided.

"The steamboats employed on the Hudson river are the first, belonging to the class of vessels navigating the Eastern waters, of which I shall make particular mention.

"The shoals in the upper part of the river, produced by the Overslaugh, have rendered it necessary that the steamboats employed in its navigation should have a small draught of water. The great trade of the river, and the crowds of passengers which are constantly travelling between New York and Albany and the intermediate towns, have also led to the adoption of separate lines of boats, one for towing barges loaded with goods, and another devoted exclusively to the conveyance of passengers. The attainment of great speed naturally became an important desideratum in the construction of the vessels employed in carrying passengers; and the success which has attended the efforts of the steamboat builders to produce vessels, combining swiftness with efficiency and perfection of workmanship, is truly wonderful, and in the highest degree creditable.

"The hulls of almost all the American steamboats, especially those which ply on the rivers, carrying no freight excepting the luggage belonging to passengers, are constructed in a very light and superficial manner. They are built perfectly flat in the bottom, and perpendicular in the sides; a cross section in the middle of the vessel, having the form of a parallelogram, with its lower corners rounded off. This construction of hull is well adapted to a navigation where the depth of water is small, and the attainment of great speed is an object of importance, as it ensures a smaller draught of water, and consequently affords less resistance to the

motion of the vessel than any other mould which has an equal area of cross section below the water line; but vessels built in this way, without a deep keel, having no hold of the water, are not wel. adapted for making sea voyages, as they cannot resist the effect of the wind, which causes them to make lee-way. It is only the great breadth of the paddle-wheels and power of the engines which enables the American boats to move steadily through the water. The breadth of the paddle-wheels is, in fact, so much additional breadth added to the beam of the vessel; for the reaction of the float-boards striking the water tends, in some measure, to counteract any tendency that the vessel may have to roll, which would otherwise be very apt to take place in the American steamers, where the machinery and boilers are placed above the level of the deck. There is no rolling motion felt in these fast boats. The rectilineal motion, however, is by no means regular. Every stroke of the engine produces a momentary acceleration in the speed, giving rise to a *see-saw* motion, resembling that of a row-boat, in which the impulse produced by every stroke of the oars is distinctly felt.

"In the American steamers the keel generally projects from two to six inches from the bottom of the hull, and is level from stem to stern. Its principal service, when the projection is so small, consists in strengthening the hull. The deck-lines of the hull, in general, begin to fall in at a distance of a few feet from the middle of the vessel. They approach each other with a gentle curve, towards the stern and bow, where they meet, and are connected by the stern-post and cutwater of the vessel. The cutwater is generally perpendicular; and the sides of the vessel, diverging from it, present a very acute angle to meet the resistance offered by the water.

"The speed of the American steamboats has excited considerable wonder in this country; and some people have been inclined to doubt the accuracy of the statements that have frequently been made regarding the extraordinary feats performed by them. Fast sailing is a property which is not possessed by all American steamboats; but that a few of those navigating the river Hudson and Long Island Sound perform their voyages safely and regularly, at a speed which far surpasses that of any European steamer hitherto built, every impartial person, who has had an opportunity of seeing the performances of the vessels in both countries, must be ready to admit.

"Some difficulties at present exist, which preclude the attainment of more than an approximation in ascertaining the maximum rate at which the steamboats on the Hudson are capable of being

propelled in still water. One of these is caused by the currents of the flowing and ebbing tide, which are felt as far as Albany, and whose velocity has never been accurately ascertained; and the other by the doubt that exists as to the actual distance of the route between New York and Albany, which has been variously stated at from 145 to 160 miles.

"A very general opinion exists in America, in which many persons possessing the best means of information concur, that the fast steamboats in that country can be propelled at the rate of eighteen miles an hour in still water, a feat which it is said has of late been often performed. I cannot vouch for the accuracy of this statement, however, from personal experience or observation; but this I can state positively, that the average length of time occupied by the steamers in making the voyage from New York to Albany is ten hours, exclusive of time lost in making stoppages, which, taking the distance at 150 miles, gives fifteen miles an hour as their average rate of motion.

"The 'Rochester' and the 'Swallow' were said to be the two swiftest boats running on the Hudson in 1837. I made a trip from Albany to New York in the 'Rochester,' on the 14th of June; on which occasion, with a view to test the vessel's speed, I carefully noted the hour of departure from Albany, the times of touching at the several towns and landing places on the river, with the reputed distances between them, the number of minutes lost at each place, and the hour of arrival at New York. Thirteen stoppages, which I found to average three minutes each, were made to land and take on board passengers. The 'Rochester' performed the voyage in ten hours and forty minutes. From this, thirty-nine minutes must be deducted for the time lost in making the thirteen stoppages, which leaves ten hours and one minute as the time during which the vessel was actually occupied in running from Albany to New York. Assuming the distance between those places to be 150 miles, the average speed of the vessel throughout the trip was 14.97 miles per hour; but even if we assume the distance to be only 145 miles, (the shortest distance I have ever heard stated,) which there is every reason to believe is too small, the average rate is still 14.47 miles per hour, the difference of five miles in the length of the route, producing a diminution in the vessel's average rate of sailing of but half a mile per hour. The current was in the 'Rochester's' favor during the first part of the voyage, but the Overslaugh shoals, and the contracted and narrow state of the navigable channel of the river for about thirty miles below Albany, checked her progress very much; and, consequently, for the first twenty-seven miles her speed was only 12.36

miles per hour. This was her average rate of sailing during the part of her course when her speed was slowest. After the first hirty miles the river expanded, affording a better navigable channel, when her speed gradually increased, and before the flowing tide checked her progress the vessel attained the maximum velocity indicated by my observations, which, between two of the stopping places, was 16.55 miles per hour. When going at this speed, it is possible that she was influenced by some slight degree of current in her favor, although it was quite imperceptible to the eye, as the flow of the tide appeared to produce a stagnation in the water of the river. At West Point we encountered the flood tide, as was very distinctly proved by the swinging of the vessels which lay at anchor in the river. After this we had an adverse current all the way to New York, a distance of about fifty miles, and the vessel's speed during this part of the voyage averaged 14.22 miles an hour. About one half of the voyage was thus performed with a favorable current, and the other half was performed under unfavorable circumstances, owing partly to the shallowness of the water and the narrowness of the channel in the upper part of the river, and partly to an adverse tide in the lower part of it. When the Rochester is pitched against another vessel and going at her full speed, her piston makes twenty-seven double strokes per minute On the voyage above alluded to, however, the piston, on an average, made about twenty-five double strokes per minute, so that the speed of 14.97 miles per hour, which she attained on that occasion, cannot be taken as her greatest ordinary rate of sailing. During the time, however, at which her speed was 16.55 miles per hour, her piston was making twenty-seven double strokes per minute, and at that time the vessel could not be far from having attained the maximum speed at which her engines are capable of propelling her through the water.

"The rate of sixteen and a half miles an hour is very great, but perhaps not more than is due to the form of the vessels, and the power of the engines by which they are propelled. The Rochester draws only four feet of water, but the power of her engine is greater than that of any steamer in this country. The construction of the American marine engines is so different from that adopted in Europe, that it is doubtful if the same rule for calculating the power is applicable in both cases.

"The disturbance created by the passage of the fast American steamers through the water is exceedingly small. The water, at the distance of twelve inches in front of their bows, presents a perfectly smooth and untroubled surface. A thin sheet of spray, composed of small globules of water, from a sixteenth to an

eighteenth of an inch in diameter, rises nearly perpendicularly in front of the cutwater to the height of three, and, in some cases which I have observed, as much as four feet, and falls again into the water on each side of the vessel. There is little or no commotion at the stern; and the diverging waves which invariably follow the steamers in this country, and break on the banks of our rivers with considerable violence, are not produced by the fast boats in America. The waves in their wake are very slight, and, as far as I could judge, seem to be nearly parallel; and the marks of the vessel's course cannot be traced to any great distance. These facts are quite in accordance with the result of some of Mr. Russell's experiments, by which he was led to conclude that 'the commotion produced in a fluid by a vessel moving through it, is much greater at velocities less than the velocity of the wave,' (which is proportioned to the depth of the water,) 'than at velocities which are greater than it.'

"The vast number of vessels on the Western waters, the peculiarity of their construction, and the singular nature of the navigation in which they are employed, make them objects of considerable interest to the traveller. We must not expect to find, however, in that class of vessels, the same display of good workmanship, and the attainment of the high velocities, which characterize the vessels on the Eastern waters. These qualifications may be very easily dispensed with, and the want of them is by no means the worst feature in the western navigation; but, what is of far more importance, too many of the vessels are decidedly unsafe; and, in addition to this, their management is intrusted to men whose recklessness of human life and property is equalled only by their ignorance and want of civilization.

"Economy would indeed seem to be the only object which the constructors of these boats have in view, and therefore, with the exception of the finery which the cabins generally display, little care is expended in their construction, and much of the workmanship connected with them is of a most superficial and insufficient kind. When the crews of these frail fabrics, therefore, engage in brisk competition with other vessels, and urge the machinery to the utmost extent of its power, it is not to be wondered at that their exertions are often suddenly terminated by the vessel taking fire, and going to the bottom, or by an explosion of the steam-boilers. Such accidents are frequently attended with an appalling loss of life, and are of so common occurrence, that they generally excite little or no attention.

"The vessels on the Western waters vary from 100 to 700 tons burden, and are generally of a heavy built, to enable them to carry

goods. They have a most singular appearance, and are no less remarkable as regards their machinery. They are built flat in the bottom, and generally draw from six to eight feet of water. The hull is covered with a deck at the level of about five feet above the water, and below this deck is the hold, in which the heavy part of the cargo is carried. The whole of the machinery rests on the first deck; the engines being placed near the middle of the vessel, and the boilers under the two smoke chimneys. The fire-doors open towards the bow, and the bright glare of light thrown out by the wood fires, along with the puffing of the steam from the escapement pipe, produce a most singular effect at night, and serve the useful purpose of announcing the approach of the vessel when it is still at a great distance. The chief object in placing the boilers in the manner described, is to produce a strong draught in the fire-place. The other end of the lower deck, which is covered in, and occupied by the crew of the vessel and the deck passengers, generally presents a scene of filth and wretchedness that baffles all description. A staircase leads from the front of the paddle-boxes on each side of the vessel, to an upper gallery about three feet in breadth. This surrounds the whole after-part of the vessel, and is the promenade of the inhabitants of the second deck. Several doors lead from the gallery into the great cabin, which extends from the funnels to within about thirty or forty feet of the stern of the vessel; the aftermost space is separated from the great cabin by a partition, and is occupied by the ladies. The large cabin contains the gentlemen's sleeping berths, and is also used as the dining-room. This part of the western steamers is often fitted up in a gorgeous style; the berths are large, and the numerous windows by which the cabin is surrounded give abundance of light, and, what is of great consequence in that scorching climate, admit a plentiful supply of fresh air.

"From the gallery surrounding the chief cabin, two flights of steps lead to the hurricane deck, which, in many of the steamers, is at least thirty feet above the level of the water. The wheelhouse, in which the steersman is placed, is erected on the forepart of this deck, and the motion is communicated to the helm by means of ropes or iron rods, in the manner already described in speaking of the Eastern steamers.

"The first cabin of a Mississippi steamboat is strangely contrasted with the scenes of wretchedness in the lower deck, and its splendor serves in some measure to distract the attention of its unthinking inmates from the dangers which lie below them. But no one who is at all acquainted with the steam engine can examine the machinery of one of those vessels, and the manner in which it

is managed, without shuddering at the idea of the great risk to which all on board are at every moment exposed.

"Explosions are of very frequent occurrence; and, with a view to cure this evil, several attempts have, at different periods, been made to introduce low-pressure engines on the Western waters, but the cheapness of high-pressure engines, and the great simplicity of their parts, which require comparatively little fine finishing and good fitting, certainly afford reasons for preferring them to low-pressure engines, in a part of the country where good workmen are scarce, and where the value of labor and materials is very great. It must also be recollected, that a condensing or low-pressure engine takes up a great deal more space than one constructed on the high-pressure principle. I do not apprehend, however, that the number of accidents would be diminished by the simple adoption of low-pressure boilers, without the strict enforcement of judicious regulations; and if those regulations were properly applied to high-pressure boilers, they would not fail to render them, perhaps, quite as safe as those boilers which are generally made for engines working on the low-pressure principle. One very obvious improvement on the present hazardous state of the Mississippi navigation, would be the enactment of a law that the pressure of the steam should in no case exceed, perhaps, fifty pounds on the square inch.

"The steamers make many stoppages to take in goods and passengers, and also supplies of wood for fuel. The liberty which they take with their vessels on these occasions is somewhat amusing, and not a little hazardous. I had a good example of this on board of a large vessel called the Ontario. She was sheered close inshore among stones and stumps of trees, where she lay for some hours taking in goods. The additional weight increased her draught of water, and caused her to heel a good deal; and when her engines were put in motion, she actually crawled into the deep water on her paddle-wheels. The steam had been got up to an enormous pressure to enable her to get off, and the volumes of steam discharged from the escapement pipe at every half stroke of the piston made a sharp sound almost like the discharge of fire-arms, while every timber in the vessel seemed to tremble, and the whole structure actually groaned under the shocks.

"During these stoppages, it is necessary to keep up a proper supply of water to prevent explosion; and the manner in which this is effected on the Mississippi is very simple. The paddle-wheel axle is so constructed, that the portions of it projecting over the hull of the vessel to which the wheels are fixed can be thrown out of gear at pleasure by means of a clutch on each side of the

vessel, which slides on the intermediate part of the axle, and is acted on by a lever. When the vessel is stopped, the paddle-wheels are simply thrown out of gear, and the engine continues to work. The necessary supply of water is thus pumped into the boiler during the whole time that the vessel may be at rest; and when she is required to get under weigh, the wheels are again thrown into gear, and revolve with the paddle-wheel shaft. The fly-wheel is useful in regulating the motion of the engine, which otherwise might be apt to suffer damage from the increase and diminution in the resistance offered to the motion of the pistons, by suddenly throwing the paddle-wheels into and out of gear. The water for the supply of the engine is first pumped into a heater, in which its temperature is raised, and is then injected into the boiler.

"I saw several vessels on the Ohio which were propelled by one large paddle-wheel placed at the stern of the vessel, but it is doubtful whether this arrangement is advantageous, as the action of the paddle-wheel, when placed in that situation, must be impeded by the float-boards impinging on water which has been disturbed by the passage of the vessel through it.

"The third class of vessels to which I have alluded, are those which navigate the lakes and the river St. Lawrence. They differ very materially from those I have already described, being more like the steamers of this country, both in their construction and appearance. Steamboats were first used on the St. Lawrence in 1812, and it is probable that they were also introduced on the lakes about the same time. The lake steamers are strongly built vessels, furnished with masts and sails, and propelled by powerful engines, some of which act on the high-pressure and some on the low-pressure principle."

Simple Origin of Important Discoveries.

It is certain, says Pliny, that the most valuable discoveries have found their orign in the most trivial accidents. As some merchants were carrying nitre, they stopped near a river which issues from Mount Carmel, and not happening to find stones for resting their kettles, they substituted in their place some pieces of nitre, which the fire gradually dissolving, mixed with the sand, and occasioned a transparent matter to flow, which, in fact, was nothing else but *glass*.

It is said that the use of *telescopes* was first discovered by one

Hansen, a spectacle-maker, at Middleburgh, in Holland, whose children playing in the shop, casually placed a convex and concave glass in such a manner, that, by looking through them at the weathercock, they observed it appeared much larger and nearer than usual, and, by their expressions of surprise, excited the attention of their father, who soon obtained great credit for this useful discovery.

Heylin, in his cosmography, tells us that the art of *steering* was discovered by a man of the name of Typhis, who took his hints for making both the rudder and helm from seeing a kite, in flying, guide her whole body by her tail.

Invention of the Safety Lamp.

This lamp, by means of which hundreds of lives have been preserved, was invented in the autumn of 1815. Sir Humphry Davy, the inventor, was led to the consideration of this subject, by an application from Dr. Gray, now Bishop of Bristol, the chairman of a society established in 1813, at Bishop-Wearmouth, to consider and promote the means of preventing accidents by fire in coal-pits. Being then in Scotland, he visited the mines on his return southward, and was supplied with specimens of fire-damp, which, on reaching London, he proceeded to examine and analyze. He soon discovered that the carburetted hydrogen gas, called fire-damp by the miners, would not explode when mixed with less than six, or more than fourteen, times its volume of air; and further, that the explosive mixture could not be fired in tubes of small diameters and proportionate lengths. Gradually diminishing these, he arrived at the conclusion that a tissue of wire in which the meshes do not exceed a certain small diameter, which may be considered as the ultimate limit of a series of such tubes, is impervious to the inflamed air; and that a lamp covered with such tissue may be used with perfect safety, even in an explosive mixture which takes fire and burns within the cage, securely cut off from the power of doing harm. Thus, when the atmosphere is so impure that the flame of a lamp itself cannot be maintained, the Davy still supplies light to the miner, and turns his worst enemy into an obedient servant. This invention, the certain source of large profit, he presented with characteristic liberality to the public. The words are preserved i which, when pressed to secure to himself the benefit of a patent he declined to do so, in conformity with the high-minded resolution which he formed, upon acquiring independent wealth, of nevei

making his scientific eminence subservient to gain. "I have enough for all my views and purposes; more wealth might be troublesome, and distract my attention from those pursuits in which I delight. More wealth could not increase my fame or happiness. It might undoubtedly enable me to put four horses to my carriage; but what would it avail me to have it said that Sir Humphry drives his carriage and four?"

Like most individuals of worth, Davy was a man of true modesty and in his dress and manners very simple. Volta, to whom he was introduced at Pavia, had attired himself in full dress to receive him, but is said to have started back with astonishment, on seeing the English philosopher make his appearance in a dress of which an English artisan would have been ashamed. The following anecdote is told of him: whilst staying for the night at a small inn in North Wales, with his friend Mr. Purkis, a third traveller entered into conversation with both, and, as happened, talked very learnedly about oxygen and hydrogen, and other matters relative to chemical science. When Davy, who had listened with great composure, had retired to rest, Mr. Purkis asked the stranger, what he thought of his friend who had just left him. "He appears," coolly replied the other, "rather a clever young man, with some general scientific knowledge:—pray what is his name?" "Humphry Davy, of the Royal Institution," coolly replied the other. "Good heavens!" exclaimed the stranger, "was that really Davy?—how have I exposed my ignorance and presumption!"

The Thames Tunnel.

As far back as the year 1802, a project was set on foot by some enterprising gentlemen, with a view of opening an archway under the Thames, between Rotherhithe and Limehouse, not far from the line of the present tunnel. The engineer selected for this enterprise was particularly qualified for such an undertaking, being an experienced Cornish miner. Having made some borings at the Horse-ferry and on the opposite side of the river, he reported that "he was firmly persuaded the undertaking would not cost so much as had been conceived." A subscription was, in consequence, raised; and a company was formed, under the denomination of the "Thames Archway Company." Surveys, plans, and estimates were made, and an act of parliament being obtained, the work was begun. The engineer commenced opera-

tions by sinking a shaft of eleven feet diameter, at three hundred and thirty feet from the line of the wharf on the Rotherhithe side. But the obstacles which he encountered from the nature of the ground increased to such a degree, as he proceeded, that at the depth of forty-two feet he was obliged to desist. A subsequent report of borings, however, having proved very favorable, an enterprising proprietor engaged to complete the shaft (reduced to eight feet diameter) to seventy-six feet, at which depth it was discovered that it would be dangerous to go deeper. At this stage of the proceedings, viz., in August, 1807, a second engineer was engaged by the company, a gentleman whose name had been coupled with very great enterprises in the mining department. Before opening the drift-way, both engineers agreed to reduce its breadth to two feet six inches at the top, and three feet at the bottom. At the depth of seventy-six feet they found the ground to consist of a *firm dry sand;* and there they opened the drift, which they carried forward in a gentle ascent. In November, 1807, when three hundred and ninety-four feet of the drift had been completed, the services of the first engineer were dispensed with, after four years and a half of hard labor. The directors then agreed to give the second engineer £1,000, by way of premium, if he succeeded in reaching the opposite shore. The drift was further extended to eight hundred and fourteen feet, through equally firm dry ground, with the precaution, which had been employed from the beginning, of a substantial planking all the way. One hundred and thirty-eight feet more were cut through a bed of calcareous rock eight feet thick. But on the 21st of December, the head of the drift had hardly entered two feet into the stratum, which lay immediately over the rock, when the roof broke down in a loose state, leaving above head a cavity large enough for a man to stand in it. It is to be observed that there was no less than thirty feet of intervening ground between the drift and the river at the time this accident happened. The engineer succeeded in filling and securing the cavity; but, such was the nature of the whole ground above the rock, that, under the influence of an extraordinary high tide, (on the 26th of January, 1808,) the ground again made its way fast in a loose state into the drift, and the river soon broke through twenty-five feet of ground. This same tide caused the destruction of the Deptford and Lewisham bridges. The engineer having succeeded in filling and closing this hole, the miners re-entered the drift, which was reduced to three feet in height, for the purpose of clearing the dangerous place. The miners had therefore, to work on their knees: however, notwith

standing every effort to attain the opposite shore, they were driven away by the frequent bursts of sand and water. The engineer having afterwards sounded the ground from above, reported that he had no doubt the two fractures communicated underneath; and therefore admitted that it was quite impracticable to go further except by means of a coffer-dam or caissons. On the 30th of March, 1809, the directors offered a reward for the most approved plan of completing the archway. Fifty-four plans having been obtained by this announcement, they were referred to the opinion of scientific men. These gentlemen reported that they were unanimously of opinion, that an archway, of any useful size, was impracticable under the Thames by an underground excavation on any of the plans that had come before them; observing, at the same time, that they did not pretend to assign limits to the ingenuity of other men. A further trial was made by a third engineer, who operated from above the river, but it proved equally fruitless. Thus ended, in 1809, all the exertions and the efforts made during nearly seven years, for the purpose of accomplishing an archway under the bed of the Thames; at the end of which period not so much as a drain had been completed, nor had the miners succeeded in working in any of those strata wherein the excavation for the archway must eventually have been effected.

Several years afterwards, Mr. Brunel was prevailed upon by one of the most active promoters of the archway enterprise (Mr. J. Wyatt) to turn his attention to the subject; and, being furnished with the documents connected with the first attempt, he devised his plan with the impression that both the excavation and the structure might be made on a full scale at once.

Before proceeding to an exposition of the plan adopted by Mr Brunel, and of the means by which he has carried it into execution, we have to state that the structure of the Thames Tunnel, as represented in the annexed view, is thirty-eight feet in width, and twenty-two feet six inches in height, externally; and that a length of six hundred feet, in the style of a double arcade, has been made, though one arch only is open to public inspection. The excavation, therefore, made under the Thames for this structure presents a sectional surface of eight hundred and fifty feet, which is equal to sixty times the area of the drift. At high water, the head of the river is about seventy-five feet *above the foot of the excavation*, and consequently three times the height of that room. These circumstances, independently of the nature of the ground, are sufficient to place the work of the Thames Tunnel among the boldest enterprises in the art of engineering.

Notwithstanding that the first attempt had contributed to dis-

courage all idea of success, there were still sufficient evidences to indicate that by beginning in the stratum of dry firm sand, and keeping close under the stratum of clay forming the bottom of the river, there was space enough to effect the object, although the nature of the intervening ground had been ascertained to be very loose in many places. All the information obtained from the miner's report concurred with the opinions of geologists in pointing out that the most eligible line for the Tunnel was to keep as near to the bottom of the river as the security of the work would permit. The first idea of the plan which appeared to the engineer best calculated for making an excavation fit for the object under so overwhelming a head of water, was suggested by the sight of a piece of a keel of a ship which had been eroded by the operation of the worm called the terido. From this he conceived it practicable, as his specification describes it, to make a circular opening of sufficient capacity at once. However, of the two modes which he described, he gave the preference to that of proceeding by forming, simultaneously, several contiguous excavations by means of an apparatus which has been denominated the *shield*. This shield, upon the whole, partakes of the character of a powerful coffer-dam, applied in a horizontal instead of the vertical direction. It consists of twelve parallel frames lying close to each other, like so many volumes in a bookcase. Each frame, being nearly twenty-two feet in height, is divided into three stories: the whole presents therefore thirty-six openings or cells. It is from these cells that the miners, operating by small quantities at a time, like so many teridos, are able to dig the ground in front, while others at the back bring up the brick structure. For locomotive action each frame is provided with two substantial legs resting on equally substantial shoes, (not unlike snow-shoes;) these legs are provided with joints, that fit the frames for a pacing movement. The shield has been pushed forward six hundred feet of its assigned career; and has left behind a substantial structure in the form of a double arcade.

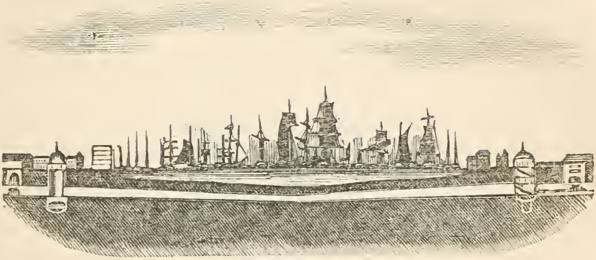
With regard to the external form of the structure, and the mode adopted for its execution, it must be obvious to persons acquainted with such matters, that the most substantial form, and the best calculated at the same time to prevent, as far as practicable, any derangement in alluvial strata of various degrees of density, is the square form, as corresponding with that mode of building which is technically called underjoining and underlaying. Thus, in fact, the bed of the river, with its contents, has been underlayed to receive the superstructure.

An indispensable requisite in a work of this nature was, that it

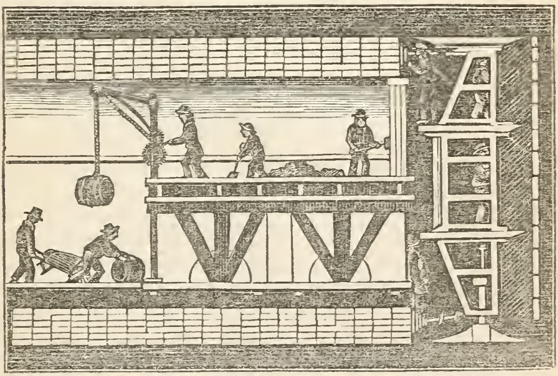
should be made proof against the greatest disasters that were to be apprehended, notwithstanding every precaution that could be taken. Mr. Brunel's plan was considered by his grace the Duke of Wellington, by Dr. Wallaston, and by those engineers and scientific men who had the opportunity of examining the designs, and of hearing the description given by the engineer, as being well calculated to accomplish the contemplated object, although some apprehensions were raised at the time as to what might result from so formidable an occurrence as an irruption of the river, considering the extent of the devastation it might cause in the ground and among the works. The engineer afforded such explanations as allayed, in some degree, those apprehensions which, it must be admitted, he has since completely dispelled by undeniable facts.

It was under these auspices that the plan was brought before the public in 1823, and that in the month of February, 1824, subscriptions were obtained to a large amount to carry it into effect, notwithstanding the novelty of the scheme, and its risks.

The company having been incorporated in 1824 by an act of parliament, the work was begun in March, 1825. A shaft fifty feet diameter was constructed, destined to form ultimately the descent for the footways. This structure was in the first instance laid upon piles, and raised to the height of forty-two feet, including a cast-iron rim, intended to act as a cutter. A steam engine of thirty-horse power was mounted on the top of this structure. In this state, the piles being removed, this tower was brought to rest upon the edge of the cast-iron rim. It is easy to comprehend, that, by clearing the ground inside, the whole must have descended. In this manner a structure, weighing about twelve hundred tons, was lowered to the depth of forty feet, through a stratum twenty-six feet deep, consisting of gravel and sand full of water, wherein the drift-makers had met with almost insurmountable obstacles. It is to be remarked, that for this, and for the whole operation of the Tunnel, the engineer did not employ a larger steam engine than had been required in the operations of the drift-way. As the body of the Tunnel was to be opened at the depth of forty feet, the shaft was continued to sixty-four feet, by underlaying, leaving the space in the side open for the horizontal work. A well, or cistern, twenty-five feet diameter, was further made at the bottom of this shaft, for draining the ground; but in sinking it a quicksand suddenly burst upon the work. This event confirmed the report of the drift-makers, and of the geologists, as to the existence of a dangerous bed of sand at about eighty to eighty-five feet from the level of high water. The shield destined



LONGITUDINAL SECTION OF THE THAMES TUNNEL,
Showing its course under the River.



VERTICAL SECTION OF THE THAMES TUNNEL,
Exhibiting the method of conducting the Work.

to precede the body of the Tunnel, was put up at the depth of forty feet. The shield consists of twelve parallel frames twenty-two feet high. These being divided into three stories, present together thirty-six cells, destined for the working of the men. The whole constitute at the same time a powerful fence against the ground. The sides and the top are lined with sliding pieces, corresponding with the sheet-piling of a coffer-dam; and at the bottom it rests upon broad shoes. For its progressive movement each frame is provided with legs, which have their action in the lower cells. By this means each frame can be moved separately; but the whole is brought forward by alternate moves, regulated by the progress of the work. Each operator provides for the security of his own cell, by covering the front with small boards, technically called polings; and, as the miners work in front, the bricklayers work at the back in forming the structure, as shown in the adjoining engraving.

The shield was entered under a substantial bed of clay, and its progress began, by about the 1st of January, 1826. It had not advanced above nine feet, when this substantial protection was found to break off at once, leaving the work open to a considerable influx of water and of fluid sand; and it resulted that for thirty-two days the progress was extremely slow: however, by the 14th of March, the shield was brought into substantial ground again. From that day to the 14th of September following, two hundred and sixty feet of tunnel had been completed; when, in consequence of a run of ground in a fluid state, a cavity was discovered to be formed above the head of the shield. A remarkable occurrence happened on that day. The engineer having occasion to meet the directors, stated to them that at the head of the tide, which was then rising, the bottom of the river would, he conceived, break down, observing at the same time that every thing was prepared to meet the case. The accident did actually occur. However, though this was the first occurrence of the kind under the river, the miners were in no way alarmed on hearing the river deposits falling over the head of the shield, accompanied with a burst of water. The cavity soon filled itself, and with additional precaution the work was continued. An occurrence somewhat similar to the preceding one took place on the 18th of October following, with equal success in its consequences. On the 2d of January (1827) three hundred and fifty feet of tunnel had been made; when, in the act of removing one of the poling-boards which cover the front of the excavation, some loose ground, of the consistency of tempered clay, impelled by the weight of an extraordinary high tide, made its way with an almost irresistible

..rce; but, with the auxiliary means which had been provided for emergencies of this nature, an irruption of the river was completely averted.

The influence of the tide upon the ground to a depth of not less than thirty feet, was a circumstance which contributed more than any other to multiply the difficulties, and to give them an awful character. In its natural state the ground is compact, even when it consists of sand or of gravel; but in consequence of an excavation on so large a scale, opening new vents for the passage or emission of water, it has resulted that some of the strata have been decomposed and softened, some portions have become even liquid, and others have been kneaded into various degrees of consistency. These circumstances, which are exemplified in the three preceding occurrences, rendered the operations excessively complicated and laborious. Other portions of the strata, consisting of round smooth pebbles, though imbedded in some adhesive substances, were occasionally found as loose as chesnuts in a cask. It resulted, from the concurrence of so many causes, that the ground, at the foundations in particular, instead of retaining its original state, as reported by the drift-makers, viz., a dry firm ground, was found to be so loose, even at the depth of several feet, that it became expedient to condense the ground before the foundations could be laid down. This was effected by means of substantial planking, compressed with a power exceeding the greatest weight which each plank was computed to carry. The original idea of forming the structure by rings of nine inches, united by the cement only, has proved the most efficient way to prevent the consequences that were to be apprehended from any derangement or disruptions that might result from partial settlements.

From the 14th of January to the 14th of April following, although the ground was in general so loose that the river deposits were sometimes found in the way of the excavation, and although the influx of water was generally excessively abundant, the progress of the work exceeded upon the whole that of any period during the course of the operation: it has been as much as fourteen feet in a week, and even three feet per day. However, in consequence of the frequent run of fluid ground, the engineer applied for and procured a diving-bell for the purpose of examining the bottom of the river. The first inspection took place on the 22d of April. A shovel and a hammer, left at the bottom of the river, were not found again upon the next visit, as expected. Some depressions were discovered in several places and were secured.

On the 12th of May, however, in the act of removing the polings in front of several cells, the ground made its way at the top of

ten frames in succession. One of the top cells, in particular, was filled several times, but by an expeditious move, and the intrepidity of one of the miners, the ground was secured and the work was brought forward. In advancing one of the middle frames, the shovel and the hammer which had been missing, were found in the way of it, having descended at least eighteen feet into the ground.

Notwithstanding the loose state of the ground, the shield had gradually gained under a more substantial covering, when several vessels, coming in at a late tide, moored just over the head of the Tunnel, where no vessels had moored since the docks had been open to the trade. It resulted from this obstruction to the stream, that those substances which protected the softer ground from the action of the tides, were washed away. The river soon made its way into the Tunnel, forming at first a transparent curtain between the shield and the brick structure. Every exertion made to oppose it proved fruitless; the river soon after broke in and filled the Tunnel. This irruption took place on the 18th of May, 1827.

On examining the hole with the diving-bell, the structure was ascertained to be perfectly sound, and the shield, to all appearance, undisturbed. The repairs were immediately proceeded with, by means of clay in bags, armed with small hazel rods: about three thousand tons of this filling, with some other soil, were required to close the hole, or rather the chasm, which was found to exceed thirty-eight feet in depth.

At this period of the proceedings, many hundred projects were sent to the directors or to the engineer, but none were found applicable to the case.

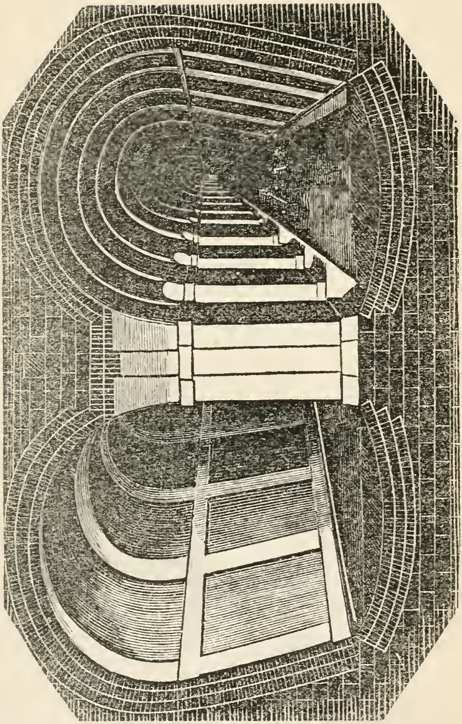
On the 21st of June the Tunnel was sufficiently clear of water to be entered; and by the middle of August the soil which had been driven into the arches was completely removed. The structure was found quite sound; but, owing to the settlement of the new ground, augmented too by the weight of the water, the frames were found separated at the head, the chain that united them having given way. Nothing can convey so just an idea of the impetuosity of the irruption, as the state in which the invert of the arch was found. There the brickwork was reduced by nearly one half of its thickness, as if it had been battered with cannon-balls of small calibre; at the thickest part of the foundation a hole was open, as if made by the fall of a fourteen-inch shell. Some heavy pieces of casting belonging to the shield had disappeared; but they were found afterwards driven into the ground as if forced by a powerful ram. In consequence of the continued depres-

sion of the new-made ground, moving too in an oblique direction, several further ruptures took place in the frames, with reports as loud as cannon-shots. The men were not, however, dismayed, even at the sensible movement of the ground: although the frames were separated by more than two feet at the head, the arches experienced no derangement whatever. The work was resumed and extended fifty feet beyond the first irruption; and, notwithstanding the disadvantages under which this additional portion was effected with a shield so very much weakened, and so much out of order, no part of the structure has been more substantially constituted than these fifty feet, which brought the whole to the middle of the low water.

In the early part of January, 1828, in consequence, in a great measure, of the interruption which had taken place during the preceding week's holidays, the ground had become looser than before. On the 12th, in particular, the greatest precautions became necessary against a manifest danger. The men were ordered out in time, except four, whom Mr. Brunel, jun., selected to remain with him. Every exertion was made to oppose the mass of earth, but the ground, swelling and rolling in, as we are told of the progress of lava, became irresistible in its progress. One of the men, having executed his part, made his escape. Suddenly, as Mr. Brunel was directing the others how to save themselves, the ground burst in like a volcanic irruption, with a tremendous crash; all the lights were blown out at once. Through this total darkness Mr. Brunel reached the shaft, but the water was at the top before him. The men collected at the top had seen the waves close upon the scene before Mr. Brunel emerged from it. The three men were not so fortunate; three others were likewise lost; but these must have been the victims of their own imprudence and curiosity, as they had not been detained in the work.

This second irruption, though still more sudden and more formidable than the first, was overcome by the same means. No less than four thousand tons of soil, chiefly clay in bags, were required to fill the chasm and effect a substantial covering. On re-entering the Tunnel, the structure was found perfectly sound; and the shield was a powerful barrier against which the bags were collected and retained by these rods with which they were armed.

In this state of things, the pecuniary resources of the company being too low to proceed with the work, the directors found themselves reduced to the necessity of discontinuing it. The ends of the arches were accordingly closed until means could be obtained to resume the undertaking. Many more plans were received by the directors at this juncture, but all were equally unavailable. It



CROSS SECTION OF THE THAMES TUNNEL,
Exhibiting the Arrangement of the Masonry.

has, however, since been resumed under favorable auspices, and at the present time the Tunnel is about completed.

The average cost of the Thames Tunnel does not exceed £6 3s. 9d. per cubic yard of the ground removed, including the structure, which contains nine hundred and sixty rods of brickwork. The average cost of the drift-way is £16 10s. per cubic yard, with no more than seven rods of brickwork.

Watchmaking in Swtizerland.

The following details are given in an abridged form from a "Report on the Commerce and Manufactures of Switzerland," by Dr. Bowring, recently laid before Parliament. A large portion of the facts were furnished to Dr. Bowring by M. Houriet, an intelligent manufacturer, who, in his communication, dated January, 1836, asks for indulgence on the plea that he is neither "a learned man nor a writer," and yet, says Dr. Bowring, "a more interesting and instructive document has seldom, I believe, been furnished."

One of the largest and most interesting branches of Swiss industry is the watchmaking trade. It is carried on to an immense and still increasing extent in the mountainous districts of Neuchatel, in the French portion of the Canton of Berne, and in the town and neighborhood of Geneva. It has been a source of wealth and comfort to many thousands of the inhabitants, who, in the seldom-visited villages of the Jura, have gathered around them a large portion of the enjoyments of life. Switzerland has long furnished the markets of France; and though the names of certain French watchmakers have obtained a European celebrity, yet Dr. Bowring was informed by M. Arago that an examination into this trade had elicited the fact that not ten watches were made in Paris in the course of a year, the immense consumption of France being furnished from Switzerland, and the Swiss works being only examined and rectified by the French manufacturers. The contraband trade into France was immense, and no custom-house regulations could stop the introduction of articles so costly and so little bulky. They are now admitted into France at six per cent. for gold, and ten per cent. for silver watches, and a considerable quantity pays this moderate duty.

The Jura mountains have been the cradle of much celebrity in the mechanical arts, particularly in those more exquisite productions of which a minute complication is the peculiar character. During the winter, which lasts from six to seven months, the inhabitants are, as it were, imprisoned in their dwellings, and occupied

in those works which require the utmost development of skilful ingenuity. Nearly one hundred and twenty thousand watches are produced annually in the elevated regions of Neuchatel. In Switzerland the most remarkable of the French watchmakers, and among them one who has lately obtained the gold medal at Paris for his beautiful watch-movements, had their birth and education: and a sort of honorable distinction attaches to the watchmaking trade. The horologers consider themselves as belonging to a nobler profession than ordinary mechanics, and do not willingly allow their children to marry into what they consider the inferior classes.

The art or trade of clockmaking was introduced into the mountains of Neuchatel in a manner worthy of notice. As early as the seventeenth century some workmen had constructed clocks with weights, but no idea had been conceived of making clocks with springs. About the end of that century, an inhabitant of the mountains, returning from a long voyage, brought with him a watch, which was an object previously unknown in the country. It was put into the hands of a skilful workman to be repaired, who succeeded in doing so, and then tried to make a similar article. He succeeded in effecting this also, notwithstanding the difficulties which lay in his way, he having to construct the tools with which he wrought, as well as all the different movements of the watch. His success naturally created a great sensation; other workmen were stimulated to try what they could do, and a new branch of industry sprung up in the mountains of Neuchatel. During the first forty or fifty years a few workmen only were employed in watchmaking; and owing to the numberless difficulties they had to surmount, to the slowness of execution caused by the absence of convenient tools, the want of proper materials, &c., the productions and profits were inconsiderable. They began at length to procure the articles of which they stood in need from Geneva, and afterwards from England; but the high prices which these articles cost induced many of the workmen to attempt to provide them for themselves. They not only thus succeeded in rivalling foreign tools, but they eventually made many superior ones till then unknown. From that period they have constantly invented other instruments in order to facilitate and perfect the art of watchmaking; and at the present moment the manufacture of watchmaking tools and appurtenances is become a branch of industry of so much importance, as to enable the inhabitants to supply them to those countries from whence they formerly imported them.

It is not more than eighty or ninety years since a few merchants began to collect together small parcels of watches, in order to sell

them in foreign markets. The success which attended these speculations induced and encouraged the population to devote themselves still more to the production of articles of ready sale; so much so, that nearly the entire inhabitants have embraced the watchmaking trade. The population has increased threefold, independently of the great number of workmen who are established in almost all the towns of Europe, in the United States of America, and even in the East Indies and China. From this period a great change has taken place in the country of Neuchatel, where, notwithstanding the barrenness of the soil and the severity of the climate, beautiful and well-built villages are everywhere to be seen, connected by easy communications, together with a very considerable and industrious population, in the enjoyment, if not of great fortunes, at least of a happy and easy independence.

"If our watches," says M. Houriet, "have attained a certain reputation of superiority, it is in a great measure to be attributed to the independence of our workmen, and to the advantage which they have derived from a careful and studied execution of the several articles intrusted to their respective and particular talents. Indeed, on the one hand, each artisan working at home, and for whomsoever pays him the best price, and on the other, the merchant having an interest to encourage by paying the best prices to those who furnish him with the best materials and work, a kind of emulation is naturally excited among the workmen to obtain a preference and an advantage. Perhaps, also, the spirit which is generally diffused among the inhabitants of mountainous countries, added to the habits and customs of our workmen, who are at the same time landed proprietors, has not a little contributed to this development of talent amongst our population. Living simply, and in the bosom of their families, occupied entirely (with the exception of a few slight agricultural cares) in the labors of their art, and not being exposed to those temptations which exist in and corrupt large societies, it is very natural that they should be more assiduous and more desirous of attaining perfection in their art; and the more so still, as they derive a greater benefit from it, their reputation and their interest are equally engaged.

"The present condition of this branch of industry is extremely prosperous, and it is with great difficulty that we can succeed in executing all the orders which we receive.

"As to the probable fate of this trade, it is even permitted to hope, and with much probability, that it is yet susceptible of extension. A watch is no longer, as it was formerly, an object of luxury, destined exclusively for the rich; it has become an article of the first necessity for every class in society: and as, together with the

increased perfection of this article, its value has at the same time considerably diminished, it is evident that a common watch, which will exactly indicate the hour of the day, is actually (by its low price) within the reach of almost every individual, who will likewise feel anxious to possess one. For this reason, and in proportion as commercial and maritime relations are extended and emancipated from the trammels in which the great central marts of commerce have involved them, so will distant nations become civilized; and it may be fairly anticipated that the art of watchmaking will form a part of the great current of improvement.

"The number of watches manufactured annually in this canton (Neuchatel) may be calculated to be from 100,000 to 120,000, of which about 35,000 are in gold, and the rest in silver. Now, supposing the first, on an average, to be worth 150 francs, and the others 20 francs, it would represent a capital of nearly 7,000,000 francs, without taking into consideration the sale of clocks and instruments for watchmaking, the amount of which is very large.

"Not only the whole of the European markets, but also those of the most distant countries, are now opened to our productions. The United States of America consume the largest proportion of our watches. There is, however, a great difference with respect to the degree of facility which is afforded to us by the several nations with whom we deal. In Austria, and in all the countries under her dominion, as well as in Sweden, our clocks and watches are prohibited, and only penetrate by fraud. In England, the duty is twenty-five per cent. for home consumption; and for the colonies, though there is in London a bonding depot, it offers too many disadvantages and impediments to permit us to make use of it: for an article of such careful and delicate construction ought not to be mixed pell-mell with grosser commodities, as it runs too great a risk of being seriously damaged. In Spain, and in most of the Italian States, the duty is equivalent to a prohibition. In France, the duty has recently been reduced sufficiently low to render smuggling unnecessary. In Russia and in the United States, the duty, though high, can still be borne. In Prussia, the duty has always been moderate, and of late years it has been reduced by one-half in favor of our productions. Finally, the States of the German and the Swiss Confederation are the only countries which have been entirely open to this species of commerce; and it has always been easy to forward to Turkey and to the Levant by the free ports of the Mediterranean. We are making arrangements with Russia for an overland trade to China."

With the exception of gold and silver for the manufacture of the watch-cases, the other materials for the construction of the works

or mechanism of the Neuchatel watches are of little value, consisting merely of a little brass and steel. The steel is imported from England, and is reckoned the best that can be procured; the brass, which was formerly brought from Holland, is now furnished by France, the French brass being now considered much superior. With respect to gold and silver, the inhabitants of Neuchatel have no other resource but to melt current money, which induces M. Houriet to suggest that an advantageous commerce might be opened up with such countries as possess the precious metals.

The spirit of adventure is very strong among the industrious inhabitants of the Jura Mountains. A great many of them have travelled into very remote countries, whence some have returned with considerable fortunes. A few years ago a watchmaker of Neuchatel found his way to China, where he amassed a handsome property by importing watches; and he returned home since, accompanied by a young Chinese, whom he caused to be instructed in the trade, and who had sailed for Canton only a few weeks before Dr. Bowring's visit.

Perpetual Motion.

An able writer in the 'Penny Magazine' has clearly shown the futility of seeking to *square the circle*, a pursuit in which, he says, persons are still engaged. How many may waste their time on such an object I have no means of knowing; not any considerable number, I should think, as nobody can expect any profit to arise even from success. At all events, such enthusiasts must be few indeed compared with those who are spending their days and nights, and exhausting their means, in the equally vain hope of discovering the perpetual motion. Professional men, employed in preparing patents, could tell of project after project submitted to them by the impatient inventor who is afraid of waiting to perfect his machine, lest his invaluable secret should get abroad, and he should be deprived of the riches which he has all but in his grasp.

Two classes of persons are inveigled into this hopeless quest. the first is the projector,—generally a man who can handle tools, and who is gifted with some small power of invention,—a faculty, as Mr. Babbage justly observes, by no means rare, and of little use unless coupled with some knowledge of what others have done before him. Of the inventions already made,—of the experiments which have been tried and have failed,—our projector is usually profoundly ignorant. What are called the laws of machanics, namely, general truths which were established by the observations

of scientific men in times past, and which are now admitted by all who take the trouble to investigate them, he has either never heard of, or chooses to set at nought without inquiry. The other class is that which finds capital. The projector, having perhaps exhausted his own funds, takes his scheme to some person who has a little money to spare, and dazzles him with the prospects of sudden and splendid wealth: little by little he is drawn into expenses which neither of them perhaps had anticipated. Failure after failure ensues, but still all is to be right at last. The fear of ridicule,—the necessity for retrieving, the one his capital, the other his credit,—these motives carry them on till the ruin of both puts a termination to their folly.

Unhappily, however, the stage is quickly occupied by other adventurers, profiting nothing by the fate of their precursors; and yet one would think that a very slight consideration of the subject would be sufficient to show the absurdity of the undertaking. What is the object aimed at? Is it to make a machine which, being once set in motion, shall go on without stopping until it is worn out? Every person engaged in the pursuit of the perpetual motion would perhaps accept this as a true statement of the object in view. Yet nothing is more easy than to make such a machine. There are from ten to twenty of them at work at this moment on the Rhine, opposite Mayence. These are water-mills in boats, which are moored in a certain part of the river; and, as the Rhine is never dry, these mills, which are simple in their construction, would go on for years,—go on, indeed, until they were worn out. But if this instance were mentioned, the projector would perceive that the statement of his object was imperfect. It must run thus: a machine which, being set in motion, shall go on till worn out without any power being employed to keep it in motion.

Probably few persons who embark in such a project sit down beforehand to consider thoroughly what it is they are about to undertake, otherwise it could hardly require much knowledge of mechanics to see the impossibility of constructing such a machine. Take as many shafts, wheels, pulleys, and springs as you please: if you throw them in a heap in the corner of your room, you do not expect them to move; it is only when put together that the wildest enthusiast expects them to be endowed with the power of self-movement; nor then unless the machine is set going. I never heard of a projector who expected his engine to set off the moment the last nail was driven, or instantly on the last stroke of the file. And why not? A machine that would continue to go of itself would begin of itself. No machine can be made which has not

some friction, which, however slight, would in a short time exhaust any power that could have been employed merely for the purpose of setting it in motion. But a machine, to be of any use, must not only keep moving itself, but *furnish power*; or, in other words, it must not only keep in motion, but it must have power to expend in some labor, as grinding corn, rolling metals, urging forward a vessel or a carriage; so that, by an arrangement of parts which of themselves have no moving power, the projector expects to make a machine, self-moving, and with the power of performing some useful task!

"Father, I have invented a perpetual motion!" said a little fellow of eight years old. "It is thus: I would make a great wheel, and fix it up like a water-wheel; at the top I would hang a great weight, and at the bottom I would hang a number of little weights; then the great weight would turn the wheel half round and sink to the bottom, because it is so heavy, and when the little weights reached the top, they would sink down because they are so many, and thus the wheel would turn round for ever." The child's fallacy is a type of all the blunders which are made on this subject. Follow a projector in his description, and if it be not perfectly unintelligible, which it often is, it always proves that he expects to find certain of his movements alternately strong and weak, not according to the laws of nature, but according to the wants of his mechanism.

If man could produce a machine which would generate the power by which it is worked, he would become a creator. All he has hitherto done,—all, I may safely predict, he ever will do,—is to mould existing power so as to make it perform his bidding. He can make the waterfall in the brook spin his cotton, or print his book by means of machinery, but a mill to pump water enough to keep itself at work he cannot make. Absurd as it may seem, the experiment has been tried; but, in truth, no scheme is too absurd for adoption by the seekers after perpetual motion. A machine, then, is a mere conductor of power into a useful channel. The wind grinds the corn,—the sails, the shafts, and the stones are only the means by which the power of the wind can be turned to that particular purpose; so it is the heat thrown out by the burning coal which performs all the multifarious operations of the steam engine, the machinery being only the connecting links between the cause and the effect.

Perhaps these remarks may induce any projector who has not yet begun, to pause on his enterprise; and may cause those who are about to advance their capital in such vain speculations, to examine the probabilities of a return for their outlay.

The Balsa.

This ingenious contrivance, like the catamarans and massulah boats of Madras, is used for landing with safety through a heavy surf. The "Balsa," which is especially employed on the coasts of South America, both east and west, exhibits a remarkable instance of the ingenuity of the human mind in overcoming those obstacles which nature has raised to the prosecution of its pursuits. It is formed of two seal skins sewed up so as to form large bags from seven to nine feet in length; these, being covered with a bituminous substance so as to be perfectly air-tight, are inflated by flexible tubes and secured by ligatures; the pipe is of sufficient length to reach the mouth of the conductor of this frail bark, who is thus enabled occasionally to replenish the bladders with air, should any have escaped. The two are securely fastened together at one end, which forms the prow of the vessel; the other ends are spread about four feet apart by a small plank, and the raft completed with small sticks covered over with matting. The manager of the balsa sits well forward, with his passengers or goods close behind him, and armed with a double-bladed paddle approaches the back of the surf, waiting for the highest wave, and contrives to keep his balsa on the top of it with her bow towards the shore till she is thrown upon the beach to the very extent that the surf reaches, and the man immediately jumps off to secure his balsa

from returning with the sea, when the passengers land without wetting the soles of their shoes. The balsa will easily carry three passengers besides the person who guides it, and is employed in landing the cargoes from merchant vessels where the violence of the surf, particularly on the shores of the Pacific, prevents the possibility of European boats passing through it without great danger. Along the coast of Peru, which is almost entirely devoid of harbors, it is the only vessel used for these purposes, and by such frail means large bags of dollars and doubloons, and bars of silver and gold, are shipped off, without the least apprehension of their safe conveyance. Balsa, which is a Spanish word, means, in a nautical sense, float or raft; the above description applies only to that kind used at sea, but there is another balsa, more simple and more frail, used in crossing rivers, an account of which is thus given by Mr. Temple in his humorous and entertaining Travels in Peru: "Take a dried bullock's hide, pinch up each of the four corners, put a stitch with a thorn to keep those corners together, and your boat is made. For use, place it upon the water bottom downwards, then put one foot immediately in the centre, and let the other follow with the most delicate caution; you are now to shrink downwards, contracting your body precisely in the manner in which, probably, in your childhood, you have *pressed a friar into a snuff-box*. When crouched down in the bottom, sundry articles are handed in and ingeniously deposited round you, until the balsa sinks to about an inch or an inch and a half; it is then considered sufficiently laden. A naked *peone* (guide) now plunges into the stream, and, taking hold of one corner of the balsa, a peone on the shore imparts a gentle impulse to your tottering bark, while the person in the water, keeping hold of the corner with one hand, strikes out with the other, and swims away with you to the opposite bank." The work from which the above extract is made, is written in so facetious and lively a strain, at the same time giving such faithful and characteristic sketches of the customs of the country, that his readers cannot fail to receive amusement as wel' as instruction.

Automata.

An automaton is a piece of mechanism, made to resemble a living creature in outward appearance, and contrived so as to perform certain actions, resembling those of the being it represents. Both in ancient and modern times, the skill of ingenious men has been

directed to contrivances of this nature, some of which have dis played wonderful powers of invention, though in general little or no utility, unless so far as they were sources of public amusement, and examples of what may be accomplished by reflection and long perseverance. Brewster, in his Natural Magic, has given a very full account of the most remarkable automata, from which this article is principally taken.

Mechanical automata of the ancients.—The ancients had attained some degree of perfection in the construction of automata. The tripods which Homer mentions as having been constructed by Vulcan for the banqueting-hall of the gods, advanced of their own accord to the table, and again returned to their place. Self-moving tripods are mentioned by Aristotle, and Philostratus informs us, in his Life of Apollonius, that this philosopher saw and admired similar pieces of mechanism among the sages of India.

Automata of Dædalus.—Dædalus enjoys also the reputation of having constructed machines that imitated the motions of the human body. Some of his statues are said to have moved about spontaneously, and Plato, Aristotle, and others have related that it was necessary to tie them, in order to prevent them from running away. Aristotle speaks of a wooden Venus, which moved about in consequence of quicksilver being poured into its interior; but Callistratus, the tutor of Demosthenes, states, with some probability, that the statues of Dædalus received their motion from the mechanical powers. Beckmann is of opinion that the statues of Dædalus differed only from those of the early Greeks and Egyptians in having their eyes open and their feet and hands free, and that the reclining posture of some, and the attitude of others, "as if ready to walk," gave rise to the exaggeration that they possessed the power of locomotion. This opinion, however, cannot be maintained with any show of reason; for if we apply such a principle in one case, we must apply it in all, and the mind would be left in a state of utter skepticism respecting the inventions of ancient times.

Wooden pigeon of Archytas.—We are informed by Aulus Gellius, on the authority of Favorinus, that Archytas of Tarentum, who flourished about four hundred years before Christ, constructed a wooden pigeon which was capable of flying. Favorinus relates, that when it had once alighted, it could not again resume its flight; and Aulus Gellius adds, that it was suspended by balancing, and animated by a concealed aura or spirit.

Automatic clock of Charlemagne.—Among the earliest pieces of modern mechanism was the curious water-clock presented to Charlemagne by the Kaliph Harun al Raschid. In the dial-plate

there were twelve small windows, corresponding with the divisions of the hours. The hours were indicated by the opening of the windows, which let out little metallic balls, which struck the hour by falling upon a brazen bell. The doors continued open till twelve o'clock, when twelve little knights, mounted on horseback, came out at the same instant, and after parading around the dial, shut all the windows, and returned to their apartments.

Automata of Muller and Turrianus.—The next automata of which any distinct account has been preserved, are those of the celebrated John Muller, or Regiomontanus, which have been mentioned by Kircher, Baptista Porta, Gassendi, Lana, and Bishop Wilkins. This philosopher is said to have constructed an artificial eagle, which flew to meet the Emperor Maximilian when he arrived at Nuremberg on the 7th June, 1470. After soaring aloft in the air, the eagle is stated to have met the emperor at some distance from the city, and to have returned and perched upon the town gate, where it waited his approach. When the emperor reached the gate, the eagle stretched out its wings, and saluted him by an inclination of its body. Muller is likewise reported to have constructed an iron fly, which was put in motion by wheel-work, and which flew about and leaped upon the table. At an entertainment given by this philosopher to some of his familiar friends, the fly flew from his hand, and after performing a considerable round, it returned again to the hand of its master.

The Emperor Charles V., after his abdication of the throne, amused himself in his later years with automata of various kinds. The artist whom he employed was Janellus Turrianus of Cremona. It was his custom after dinner to introduce upon the table figures of armed men and horses. Some of these beat drums, others played upon flutes, while a third set attacked each other with spears. Sometimes he let fly wooden sparrows, which flew back again to their nest. He also exhibited corn-mills so extremely small that they could be concealed in a glove, yet so powerful that they could grind in a day as much corn as would supply eight men with food for a day.

Camus's carriage.—The next piece of mechanism of sufficient interest to merit our attention is that which was made by M. Camus for the amusement of Louis XIV. when a child. It consisted of a small coach, which was drawn by two horses, and which contained the figure of a lady within, with a footman and page behind. When this machine was placed at the extremity of a table of the proper size, the coachman smacked his whip, and the horses instantly set off, moving their legs in a natural manner, and drawing the coach after them When the coach reached the op-

posite edge of the table, it turned sharply at a right angle, and proceeded along the adjacent edge. As soon as it arrived opposite the place where the king sat, it stopped; the page descended and opened the coach door; the lady alighted, and with a courtesy presented a petition, which she held in her hand, to the king. After waiting some time she again courtesied and re-entered the carriage. The page closed his door, and having resumed his place behind, the coachman whipped his horses and drove on. The footman, who had previously alighted, ran after the carriage, and jumped up behind into his former place.

Degennes' mechanical peacock.—Not content with imitating the movements of animals, the mechanical genius of the 17th and 18th centuries ventured to perform by wheels and pinions the functions of vitality. We are informed by M. Lobat, that General Degennes, a French officer who defended the colony of St. Christopher's against the English forces, constructed a peacock which could walk about as if alive, pick up grains of corn from the ground, digest them as if they had been submitted to the action of the stomach, and afterward discharge them in an altered form. Degennes is said to have invented various machines of great use in navigation and gunnery, and to have constructed clocks without weights or springs.

Vaucanson's duck.—The automaton of Degennes probably suggested to M. Vaucanson the idea of constructing his celebrated duck, which excited so much interest throughout Europe, and which was perhaps the most wonderful piece of mechanism that was ever made. Vaucanson's duck exactly resembled the living animal in size and appearance. It executed accurately all its movements and gestures, it ate and drank with avidity, performed all the quick motions of the head and throat which are peculiar to the living animal, and, like it, it muddled the water which it drank with its bill. It produced also the sound of quacking in the most natural manner. In the anatomical structure of the duck the artist exhibited the highest skill. Every bone in the real duck had its representative in the automaton, and its wings were anatomically exact. Every cavity, apophysis, and curvature was imitated, and each bone executed its proper movements. When corn was thrown down before it, the duck stretched out its neck to pick it up, it swallowed it, digested it, and discharged it in a digested condition. The process of digestion was effected by chemical solution, and not by trituration, and the food digested in the stomach was conveyed away by tubes to the place of its discharge.

The automata of Vaucanson were imitated by one Du Moulin,

a silversmith, who travelled with them through Germany in 1752, and who died at Moscow in 1765. Beckmann informs us that he saw several of them after the machinery had been deranged; but that the artificial duck, which he regarded as the most ingenious, was still able to eat, drink, and move. Its ribs, which were made of wire, were covered with duck's feathers, and the motion was communicated through the feet of the duck by means of a cylinder and fine chains like that of a watch.

Drawing and writing automata.—Various pieces of mechanism of wonderful ingenuity have been constructed for the purposes of drawing and writing. One of these, invented by M. Le Droz, the son of the celebrated Droz of Chaux le Fonds, has been described by Mr. Collinson. The figure was the size of life. It held in its hand a metallic style, and when a spring was touched so as to release a detent, the figure immediately began to draw upon a card of Dutch vellum previously laid under its hand. After the drawing was executed on the first card, the figure rested. Other five cards were then put in in succession, and upon these it delineated in the same manner different subjects. On the first card it drew "elegant portraits and likenesses of the king and queen facing each other;" and Mr. Collinson remarks, that it was curious to observe with what precision the figure lifted up its pencil in its transition from one point of the drawing to another without making the slightest mistake.

Maillardet's conjurer.—M. Maillardet has executed an automaton which both writes and draws. The figure of a boy kneeling on one knee holds a pencil in his hand. When the figure begins to work, an attendant dips the pencil in ink, and adjusts the drawing-paper upon a brass tablet. Upon touching a spring the figure proceeds to write, and when the line is finished its hand returns to dot and stroke the letters when necessary. In this manner it executes four beautiful pieces of writing in French and English, and three landscapes, all of which occupy about one hour.

One of the most popular pieces of mechanism which we have seen is the magician constructed by M. Maillardet for the purpose of answering certain given questions. A figure, dressed like a magician, appears seated at the bottom of a wall, holding a wand in one hand and a book in the other. A number of questions ready prepared are inscribed on oval medallions, and the spectator takes any of these which he chooses, and to which he wishes an answer, and having placed it in a drawer ready to receive it, the drawer shuts with a spring till the answer is returned. The magician then rises from his seat, bows his head, describes circles with his wand, and consulting the book as if in deep thought, he lifts it towards

his face. Having thus appeared to ponder over the proposed question, he raises his wand, and striking with it the wall above his head, two folding-doors fly open, and display an appropriate answer to the question. The doors again close, the magician resumes his original position, and the drawer opens to return the medallion. There are twenty of these medallions, all containing different questions, to which the magician returns the most suitable and striking answers. The medallions are thin plates of brass of an elliptical form, exactly resembling each other. Some of the medallions have a question inscribed on each side, both of which the magician answers in succession. If the drawer is shut without a medallion being put into it, the magician rises, consults his book, shakes his head, and resumes his seat. The folding-doors remain shut, and the drawer is returned empty. If two medallions are put into the drawer together, an answer is returned only to the lower one. When the machinery is wound up, the movements continue about an hour, during which time about fifty questions may be answered. The inventor stated that the means by which the different medallions acted upon the machinery, so as to produce the proper answers to the questions which they contained, were extremely simple.

The same ingenious artist has constructed various other automata, representing insects and other animals. One of these was a spider entirely made of steel, which exhibited all the movements of the animal. It ran on the surface of a table during three minutes, and to prevent it from running off, its course always tended towards the centre of the table. He constructed likewise a caterpillar, a lizard, a mouse, and a serpent. The serpent crawls about in every direction, opens its mouth, hisses, and darts out its tongue.

Benefits derived from the passion for automata.—Ingenious and beautiful as all these pieces of mechanism are, and surprising as their effects appear even to scientific spectators, the principal object of their inventors was to astonish and amuse the public. We should form an erroneous judgment, however, if we supposed that this was the only result of the ingenuity which they displayed. The passion for automatic exhibitions which characterized the 18th century, gave rise to the most ingenious mechanical devices, and introduced among the higher orders of artists habits of nice and accurate execution in the formation of the most delicate pieces of machinery. The same combination of the mechanical powers which made the spider crawl, or which waved the tiny rod of the magician, contributed in future years to purposes of higher import. Those wheels and pinions, which almost eluded our senses by their minuteness, reappeared in the stupendous mechanism of our spinning-machines and our steam-engines. The elements of the tum-

bling puppet were revived in the chronometer, which now conducts navies through the ocean; and the shapeless wheel which directed the hand of the drawing automaton, has served in the present age to guide the movements of the tambouring engine. Those mechanical wonders which in one century enriched only the conjurer who used them, contributed in another to augment the wealth of the nation; and those automatic toys which once amused the vulgar, are now employed in extending the power and promoting the civilization of our species. In whatever way, indeed, the power of genius may invent or combine, and to whatever low or even ludicrous purposes that invention or combination may be originally applied, society receives a gift which it can never lose; and though the value of the seed may not be at once recognised, and though it may lie long unproductive in the ungenial till of human knowledge, it will some time or other evolve its germ, and yield to mankind its natural and abundant harvest.

Duncan's tambouring machine.—The tambouring of muslins, or the art of producing upon them ornamental flowers and figures, has been long known and practised in Britain, as well as in other countries; but it was not long before the year 1790 that it became an object of general manufacture in the west of Scotland, where it was chiefly carried on. At first it was under the direction of foreigners; but their aid was not long necessary, and it speedily extended to such a degree as to occupy either wholly or partially more than 20,000 females. Many of these laborers lived in the neighborhood of Glasgow, which was the chief seat of the manufacture, but others were scattered through every part of Scotland, and supplied by agents with work and money. In Glasgow, a tambourer of ordinary skill could not in general earn more than five or six shillings a week by constant application; but to a laboring artisan, who had several daughters, even these low wages formed a source of great wealth. At the age of five years, a child capable of handling a needle was devoted to tambouring, even though it could not earn more than a shilling or two in a week; and the consequence of this was, that female children were taken from school, and rendered totally unfit for any social or domestic duty. The tambouring population was therefore of the worst kind, and it must have been regarded as a blessing rather than as a calamity, when the work which they performed was intrusted to regular machinery.

Mr. John Duncan of Glasgow, the inventor of the tambouring machinery, was one of those unfortunate individuals who benefit their species without benefiting themselves, and who died in the meridian of life the victim of poverty and of national ingratitude. He conceived the idea of bringing into action a great number of

needles at the same time, in order to shorten the process by manual labor, but he at first was perplexed about the diversification of the pattern. This difficulty, however, he soon surmounted by employing two forces at right angles to each other, which gave him a new force in the direction of the diagonal of the parallelogram, whose sides were formed by the original forces. His first machine was very imperfect; but after two years' study he formed a company, at whose expense six improved machines were put in action, and who secured the invention by a patent. At this time the idea of rendering the machine automatic had scarcely occurred to him; but he afterward succeeded in accomplishing this great object, and the tambouring machines were placed under the surveillance of a steam-engine. Another patent was taken for these improvements. The reader who desires to have a minute account of these improvements, and of the various parts of the machinery, will be amply gratified by perusing the inventor's own account of the machinery in the article CHAIN WORK in the Edinburgh Encyclopedia. At present it will be sufficient to state, that the muslin to be tamboured was suspended vertically in a frame which was capable of being moved both in a vertical and a horizontal direction. Sixty or more needles lying horizontally occupied a frame in front of the muslin web. Each of these working needles, as they are called, was attended by a feeding-needle, which, by a circular motion round the working-needle, lodged upon the stem of the latter the loop of the thread. The sixty needles then penetrated the web, and in order that they might return again without injuring the fabric, the barb or eye of the needle, which resembled the barb of a fishing-hook, was shut by a slider. The muslin web then took a new position by means of the machinery that gave it its horizontal and vertical motion, so that the sixty needles penetrated it at their next movement at another point of the figure or flower. This operation went on till sixty flowers were completed. The web was then slightly wound up, that the needles might be opposite that part of it on which they were to work another row of flowers.

The flowers were generally at an inch distance, and the rows were placed so that the flowers formed what are called diamonds. There were seventy-two rows of flowers in a yard, so that in every square yard there were nearly four thousand flowers, and in every piece of ten yards long forty thousand. The number of loops or stitches in a flower varied with the pattern, but on an average there were about thirty. Hence the number of stitches in a yard were one hundred and twenty thousand, and the number in a piece is one million two hundred thousand. The average work done in a week by one machine was fifteen yards, or sixty thousand

flowers, or one million eight hundred thousand stitches; and by comparing this with the work done by one person with the hand, it appears that the machine enabled one person to do the work of twenty-four persons.

Watt's statue turning machinery.—One of the most curious and important applications of machinery to the arts which has been suggested in modern times was made by the late Mr. Watt, in the construction of a machine for copying or reducing statues and sculpture of all kinds. The art of multiplying busts and statues, by casts in plaster of Paris, has been the means of diffusing a knowledge of this branch of the fine arts; but from the fragile nature of the material, the copies thus produced were unfit for exposure to the weather, and therefore ill calculated for ornamenting public buildings, or for perpetuating the memory of public achievements. A machine, therefore, which is capable of multiplying the labors of the sculptor in the durable materials of marble or of brass was a desideratum of the highest value, and one which could have been expected only from a genius of the first order. During many years Mr. Watt carried on his labors in secret, and he concealed even his intention of constructing such a machine. After he had made considerable progress in its execution, and had thought of securing his invention by a patent, he learned that an ingenious individual in his own neighborhood had been long occupied in the same pursuit; and Mr. Watt informed me that he had every reason to believe that this gentleman was entirely ignorant of his labors. A proposal was then made that the two inventors should combine their talents, and secure the privilege by a joint patent; but Mr. Watt had experienced so frequently the fatal operation of our patent laws, that he saw many difficulties in the way of such an arrangement, and he was unwilling, at his advanced age, to embark in a project so extensive, and which seemed to require for its successful prosecution all the ardor and ambition of a youthful mind. The scheme was therefore abandoned; and such is the unfortunate operation of our patent laws, that the circumstance of two individuals having made the same invention has prevented both from bringing it to perfection, and conferring a great practical benefit upon their species. The machine which Mr. Watt had constructed had actually executed some excellent pieces of work. I have seen in his house at Heathfield copies of basso-relievos, and complete statues of a small size; and some of his friends have in their possession other specimens of its performance.

Babbage's calculating machine.—Of all the machines which have been constructed in modern times, the calculating machine

is doubtless the most extraordinary. Pieces of mechanism for performing particular arithmetical operations have been long ago constructed, but these bear no comparison either in ingenuity or in magnitude to the grand design conceived and nearly executed by Mr. Babbage. Great as the power of mechanism is known to be, yet we venture to say that many of the most intelligent of our readers will scarcely admit it to be possible that astronomical and navigation tables can be accurately computed by machinery; that the machine can itself correct the errors which it may commit; and that the results of its calculations when absolutely free from error, can be printed off, without the aid of human hands, or the operation of human intelligence. All this, however, Mr. Babbage's machine can do; and as I have had the advantage of seeing it actually calculate, and of studying its construction with Mr. Babbage himself, I am able to make the above statement on personal observation. The calculating machine now constructing under the superintendence of the inventor has been executed at the expense of the British government, and is of course their property. It consists essentially of two parts—a calculating part and a printing part, both of which are necessary to the fulfilment of Mr. Babbage's views, for the whole advantage would be lost if the computations made by the machine were copied by human hands and transferred to types by the common process. The greater part of the calculating machinery is already constructed, and exhibits workmanship of such extraordinary skill and beauty that nothing approaching to it has been witnessed. In order to execute it, particularly those parts of the apparatus which are dissimilar to any used in ordinary mechanical constructions, tools and machinery of great expense and complexity have been invented and constructed; and in many instances contrivances of singular ingenuity have been resorted to, which cannot fail to prove extensively useful in various branches of the mechanical arts.

The drawings of this machinery, which form a large part of the work, and on which all the contrivance has been bestowed, and all the alterations made, cover upwards of *four hundred square feet of surface*, and are executed with extraordinary care and precision.

In so complex a piece of mechanism, in which interrupted motions are propagated simultaneously along a great variety of trains of mechanism, it might have been supposed that obstructions would arise, or even incompatibilities occur, from the impracticability of foreseeing all the possible combinations of the parts; but this doubt has been entirely removed, by the constant

employment of a system of mechanical notation invented by Mr. Babbage, which places distinctly in view at every instant the progress of motion through all the parts of this or any other machine; and by writing down in tables the times required for all the movements, this method renders it easy to avoid all risk of two opposite actions arriving at the same instant at any part of the engine.

In the printing part of the machine less progress has been made in the actual execution than in the calculating part. The cause of this is the greater difficulty of its contrivance, not for transferring the computations from the calculating part to the copper or other plate destined to receive it, but for giving to the plate itself that number and variety of movements which the forms adopted in printed tables may call for in practice.

The practical object of the calculating engine is to compute and print a great variety and extent of astronomical and navigation tables, which could not be done without enormous intellectual and manual labor, and which, even if executed by such labor, could not be calculated with the requisite accuracy. Mathematicians, astronomers, and navigators do not require to be informed of the real value of such tables; but it may be proper to state, for the information of others, that *seventeen* large folio volumes of logarithmic tables alone were calculated at an enormous expense by the French government; and that the British government regarded these tables to be of such national value, that they proposed to the French Board of Longitude to print an *abridgment* of them at the joint expense of the two nations, and offered to advance £5000 for that purpose. Besides logarithmic tables, Mr. Babbage's machine will calculate tables of the powers and products of numbers, and all astronomical tables for determining the positions of the sun, moon, and planets; and the same mechanical principles have enabled him to integrate innumerable equations of finite differences, that is, when the equation of differences is given, he can, by setting an engine, produce at the end of a given time any distant term which may be required, or any succession of terms commencing at a distant point.

Besides the cheapness and celerity with which this machine will perform its work, the *absolute accuracy* of the printed results deserves especial notice. By peculiar contrivances, any small error produced by accidental dust or by any slight inaccuracy in one of the wheels, is corrected as soon as it is transmitted to the next, and this is done in such a manner as effectually to prevent any accumulation of small errors from producing an erroneous figure in the result.

Description of the Automaton Chess-player.

The Chess Automaton was the sole invention of Wolffgang de Kempelen, a Hungarian gentleman, Aulic counsellor to the royal chamber of the domains of the emperor in Hungary, and celebrated for great genius in every department of mechanics. From a boy, he had trod in the path of science, and was incontestably of first-rate capabilities as a mechanician and engineer Invention was his hobby, and he rode it furiously, even to the partial impoverishment of his means. M. de Kempelen, being at Vienna in the year 1796, was invited by the empress Maria Theresa to be present at the representation of certain magnetic games, or experiments about to be shown in public at the imperial court by M. Pelletier, a Frenchman. During the exhibition, De Kempelen, being honored by a long conversation with his sovereign, was induced casually to mention that he thought he could construct a machine, the powers of which should be far more surprising, and the deception more complete, than all the wonders of magnetism just displayed by Pelletier. At this declaration, the curiosity of the empress was naturally excited; and, with true female eagerness for novelty, she drew from De Kempelen a promise to gratify her wishes, by preparing an early and practical proof of his bold assertion. The artist returned to his modest dwelling at Presburg, and girded up his loins to the task. He kept his word with his imperial mistress; and in the following year presented himself once more at the court of Vienna, accompanied by the Automaton Chess-player. Need we say that its success was triumphantly complete?

The Chess-player was a figure as large as life, clothed in a Turkish dress, sitting behind a large square chest or box, three feet and a half long, two feet deep, and two and a half high. The machine ran on castors, and was either seen on the floor when the doors of the apartment were thrown open, or was wheeled into the room previous to the commencement of the exhibition. The Turkish Chess-player sat on a chair fixed to the square chest; his right arm rested on the table, and in the left he held a pipe, which was removed during the game, as it was with that he made the moves. A chess-board eighteen inches square, and bearing the usual number of pieces, was placed before the figure. The exhibiter then announced to the spectators his intention of showing the mechanism: and after having unlocked the doors and shown every part of the machine, to prove that it was impossible for any one to be concealed within, the Automaton was ready for play An opponent having been found among the company, the figure took the

first move. At every move made by the Automaton, the wheels of the machine were heard in action; the figure moved its head, and seemed to look over every part of the chess-board. When it gave its check to its opponent, it shook its head *thrice*, and only *twice* when it checked the queen. It likewise shook its head when a false move was made, replaced the adversary's piece on the square from which it was taken, and took the next move itself. In general, though not always, it won the game.

During the progress of the game the exhibiter often stood near the machine, and wound it up like a clock after it had made ten or twelve moves. At other times he went to a corner of the room, as if it were to consult a small square box, which stood open for this purpose.

The chess-playing machine, as thus described, was exhibited after its completion in Presburg, Vienna, and Paris, to thousands, and in 1783 and 1784 it was exhibited in London and different parts of England, without the secret of its movements having been discovered. Its ingenious inventor, who was a gentleman and a man of education, never pretended that the Automaton itself really played the game. On the contrary, he distinctly stated "that the machine was a *bagatelle*, which was not without merit in point of mechanism, but that the effects of it appeared so marvellous only from the boldness of the conception, and the fortunate choice of the methods adopted for promoting the illusion."

Upon considering the operations of this Automaton, it must have been obvious that the game of chess was performed either by a person enclosed in the chest or by the exhibiter himself. The first of these hypotheses was ingeniously excluded by the display of the interior of the machine; for as every part contained more or less machinery, the spectator invariably concluded that the smallest dwarf could not be accommodated within, and this idea was strengthened by the circumstance that no person of this description could be discovered in the suite of the exhibiter. Hence the conclusion was drawn that the exhibiter actuated the machine either by mechanical means conveyed through its feet, or by a magnet concealed in the body of the exhibiter. That mechanical communication was not formed between the exhibiter and the figure was obvious from the fact that no such communication was visible, and that it was not necessary to place the machine on any particular part of the floor. Hence the opinion became very prevalent that the agent was a magnet; but even this supposition was excluded, for the exhibiter allowed a strong and well-armed loadstone to be placed upon the machine during the progress of the game: had the moving power been a magnet, the whole action of the ma-

chine would have been deranged by the approximation of a load stone concealed in the pockets of any of the spectators.

The Chess-player continued the wonder of all Europe for a period of over sixty years, without the secret of its movement being divulged, though many were the attempts to unravel the mystery. It was exhibited in all the courts of Europe, and even kings condescended to try a game. Among other monarchs whose curiosity was excited was Eugene Beauharnois, then king of Bavaria, who bought the machine in order to ascertain the secret. Dismissing his courtiers from the room, the king then locked the door, and every precaution was taken to ensure his acquiring a sole knowledge of the hidden enigma. The prince was left alone with the demonstrator: the latter then unhesitatingly and in silence flung open simultaneously all the doors of the chest; and prince Eugene saw—*what he saw!*

Napoleon, himself a chess-player, honored the Automaton by playing a game in person against it. The contest was marked by an interesting circumstance. Half a dozen moves had barely been made, when Bonaparte, purposely, to test the powers of the machine, committed a false move; the Automaton bowed, replaced the offending piece, and motioned to Napoleon that he should move correctly. Highly amused, after a few minutes the French chief again played an illegal move. This time the Automaton without hesitation snatched off the piece which had moved falsely, confiscated it, and made his own move. Bonaparte laughed, and for the third time, as if to put the patience of his antagonist to a severe trial, played a false move. The Automaton raised his arm, swept the whole of the pieces from the board, and declined continuing the game!

While the machine was exhibiting in England, in 1785, a Mr. Philip Thicknesse printed a pamphlet in which he denounced the Automaton as a piece of imposture in no measured terms. He assumed that a child was confined in the chest, from ten to fourteen years of age, who played the game; but added, absurdly enough, that Master Johnny saw the state of the board reflected from a looking-glass in the ceiling. He had previously discovered a case of curious imposture worth quoting.

"Forty years since," writes Thicknesse, "I found three hundred people assembled to see, at a shilling each, a coach go without horses. Mr. Quin, the Duke of Athol, and many persons present, were angry with me for saying that it was trod round by a man within the hinder wheel; but a small paper of snuff put into the wheel, soon convinced all around that it could not only move, but *sneeze, too, like a Christian!*" We wonder how De Kempelen

would have met a proposition to throw an ounce or two of snuff upon speculation among his springs and levers?

Notwithstanding all the attempts, the secret of the Automaton Chess-player *was never solved,* until one of the persons implicated in the fraud turned king's evidence. Several persons almost hit the mark; but none fairly planted his arrow in the gold. *The man who really played the Chess-Automaton was concealed in the chest* Such, in half a dozen words, is the sum and substance of the whole truth of the contrivance; but the manner in which his concealment was managed is as curious as it is ingenious.

He sat on a low species of stool, moving on castors, or wheels, and had every facility afforded him of changing and shifting his position, like an eel. While one part of the machine was shown to the public, he took refuge in another; now lying down, now kneeling; placing his body in all sorts of positions, studied beforehand, and all assumed in regular rotation, like the A B C of a catechism. The interior pieces of clock-work—the wheels and make-weight apparatus, were all equally moveable; and additional assistance was thus yielded to the fraud. Even the trunk of the Automaton was used as a hiding-place, in its turn, for part of the player's body. A very short amount of practice, by way of rehearsal, was found sufficient to meet the purposes of the occasion; and one regular order being observed by the two confederates as to the opening the machine, a mistake rarely or never occurred. Should any thing go radically wrong, the prisoner had the means of telegraphing his jailer, and the performance could be suspended.

"But," says the reader, "what becomes of the vast apparatus of wheels, springs, levers, and caskets? Why did Maelzel require to wind up his man of wood and brass?" The answer is short. These things were the dust thrown in the eyes of the public. The mind of the gaping spectator dwelt on the sound of the springs and wheels, and was thus diverted from the main question. Every adjunct that intellect could devise was skilfully superadded, to enhance the marvel. The machine was railed off, for a *now* tolerably clear reason; and a lighted candle having been first introduced into the body of the Automaton, to show the interior, *at a moment nothing could be seen,* was purposely left burning close at hand, in order to prevent any inopportune rays of light flashing from the interior, where a second candle was necessarily in process of ignition.

The director of the Automaton was quietly seated, then, in the interior. All public inspection over, and the doors being safely closed, he had only to make himself as comfortable as he could

under the existing circumstances. A wax candle supplied him with light, which the candle burning outside prevented being observed; and due measures were taken that he should not die for want of oxygen. Whether he was furnished with meat, and wine, these deponents say not.

To direct the arm of the Automaton, the concealed confederate had but to set in motion a simple sort of spring, which caused its fingers to grasp the man he chose to play, and guide it to the performance of its task. To make the figure articulate check, nod its head, or perform other fooleries, similar strings, or wires, required but a pull. It must be observed, that care was taken that the performance should never last so long as to fatigue the player to exhaustion. We have before remarked, that the Automaton's chess-board and men were placed in public view before him. The concealed player possessed in the interior a second, and smaller board, with the men pegged into it, as if for travelling. On this he repeated the move played by the antagonist of the Automaton, and on this he likewise concocted his scheme of action, and made his answer before playing it on the Automaton's own board.

A very interesting and ingenious part of the secret consists in the manner in which the move played by the stranger was communicated to the concealed artist; and on this, in point of reality, turned the whole thing. A third chess-board, blank, with the squares numbered according to the usual mode of chess notation, was fixed, as it were, in the ceiling of the interior; thus forming the reverse of the table on which the Automaton really appeared to play. Now the men with which the Automaton conducted his game, were all duly magnetized at the foot; and the move being made above, the magnets on the pieces moved set in motion certain knobs, or metallic indices, adapted to each square of the board on the reverse; and thus was the requisite knowledge of the move played communicated to Jack-in-the-box. To illustrate this more clearly would require the aid of engravings; but we have given the explanation at least sufficiently distinct for our purpose. The real Simon Pure, shut up in his cell, saw by the light of his taper the metallic knobs or indices above, vibrating, so as to mark the move just played. He repeated this move on his own little board, calculated his answering "*coup*," and guided the Automaton's fingers, in order to its being duly performed. The happy association of magnetism with the figure, thus hit upon by De Kempelen, was probably suggested to him by the magnetic experiments of Pelletier, at the court of the empress.

Tedious as a "twice told tale," is the dwelling too long on the reading of a riddle. When known, its solution seems simple

enough; but the difficulty lies in its original construction. The Automaton Chess-player affords strong evidence of the fallibility of human judgment and human testimony. Thousands of individuals have seen its performance, who would have had no scruple about taking their oaths that they had viewed the whole of the engine at once. In this respect, the ingenuity displayed by its original constructor is above praise. Man loves so to be duped!

The history of the Chess-playing Automaton, subsequently to 1820, may be shortly summed up. Having travelled over the greater part of Europe, it was transported to the United States of America, where for a time it proved that the natives of the New World were made of the same stuff as their elder brethren. Jonathan dropped his dollars freely; and the calculating spirit of the land of stripes and stars, slumbered beneath the spell of Maelzel's magic. A German accompanied it, as holding the important post of invisible demonstrator, ordinary and extraordinary.

Carrying out the same principle of conduct, the Automaton subsequently took to playing whist, as well as chess. For some years, latterly, the figure has lain in a state of inglorious repose in a warehouse at New Orleans; and there we leave him, fearing the word *resurgam* may not be applied to its escutcheon. A similar bubble once blown becomes forever exploded in its pristine form.

Many must be the adventures of the Automaton, lost, unhappily, to the knowledge of man. A being that kept so much *good company*, during so long a space of time, must, indeed, have gone through an infinity of interesting events. In this age of autobiography, when so many wooden men and women have the assurance to thrust their personal memoirs on the world, a book on the life and adventures of the Automaton Chess-player would surely be received with proportionate interest. We ourselves recollect once hearing some amusing anecdotes of the thing from Mouret himself, the individual who for many years was concealed within the machine. Our limits permit our quoting but a couple of these logwood reminiscences, which we quote by way of wind-up.

In a journey once through a remote part of Germany, the Automaton set up his tent in a small town, where a professor of legerdemain being already in possession of the field, a clash between the interests of the two parties was unavoidable. The Automaton, as the monster of the late arrival, naturally put the conjurer on the shelf; and the poor Hocus-pocus, in the energies developed by famine, conversant as he was with the art he professed, discovered his rival's secret the first time he witnessed the show. Backed by an accomplice, the conjurer raised a sudden cry of "*Fire! fire!*" The spectators began to rush forth in alarm; and the Automaton,

violently impelled by the struggles of its inward man, suddenly rolled head over heels on the floor. Maelzel flew to the rescue and dropped the curtain, before terror had quite driven the imprisoned imp to burst its chain, and rush to daylight.

On another occasion, Messrs. Maelzel and Mouret were exhibiting the Automaton at Amsterdam, when it happened that the former was indebted in a considerable sum of money, relatively speaking, to his agent for his services. In fact, Maelzel, acting on the philosophical aphorism of "base is the slave who pays," had not given poor Mouret a shilling for a twelvemonth; and the latter found that, although a spirit of darkness, he could not live upon air. Mouret was lodged and boarded, but wanted also to eat. It so chanced, under these circumstances, that one day the king of Holland sent a messenger to engage the chief part of the exhibition-hall, that morning, for himself and court; and kindly seconded his royal command by the sum of three thousand florins, sent by the same courier. Maelzel proclaims the good tidings; a splendid breakfast is prepared; Mouret is pressed to eat and drink; and the parties are naturally delighted at the pleasing prospect of checkmating royalty. Maelzel hastens to arrange every preparation for receiving the Dutch monarch with "all the honors." The exhibition was to commence at half-past twelve; but, although noon had struck on every clock in the city, Mouret was not at his post. Maelzel inquires the reason, and is told that Mouret has got a fever, and gone to bed. The German flew to the Frenchman's chamber, and found half the story at least to be correct; for there, sure enough, lay Mouret, snugly tucked up in the blankets.

"What is the meaning of this?"

"I have a fever."

"But you were very well just now?"

"Yes; but this disorder—*O ciel!*—has come on suddenly."

"But the king is coming."

"Let him go back again!"

"But what shall I say to him?"

"Tell him—*mon Dieu!*—the Automaton has a sore throat."

"Can you jest at such a moment? Consider the money I have received, and that we shall have the saloon full."

"Well, Mynheer Maelzel, you can return the money."

"Pray, pray, get up!"

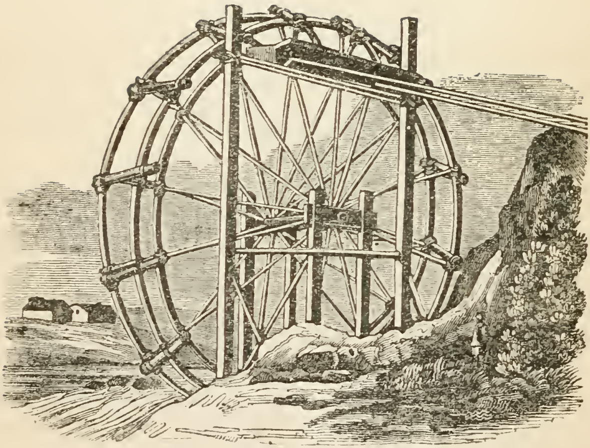
"I cannot."

"What can I do to restore you?"

"Pay me the fifteen hundred francs you owe me!"

"This evening?"

"No; pay me now—this moment, or I leave not my bed!"



CHINESE IRRIGATION WHEEL.

The case was urgent, and the means of restoration to health, however desperate, must be adopted. With a heavy sigh, Maelzel told down the cash; and never had the Automaton played with so much inward unction as he did that morning. The king declined compromising royalty by entering the lists himself; but placed his minister-of-war in the opposition chair, and graciously condescended to offer his royal advice in each critical situation of the pieces. The coalition was beaten, and the surrounding courtiers, of course, attributed defeat solely to the bad play of the minister of-war!

Chinese Bamboo Irrigation-wheel.

The Chinese irrigation-wheel, which is turned by the current of the stream, varies from twenty to thirty feet or more in height, according to the elevation of the bank; and when once erected, a constant supply of water is poured by it into a trough, on the summit of the river's side, and conducted in channels to all parts of the sugar plantations. One is at a loss which most to admire, the cleverness and efficiency, or the cheapness and simplicity of the contrivance.

The props of the wheel are of timber, and the axis is a cylinder of the same material; but every other portion of the machine exhibits some modification or other of the bamboo, even to the fastenings and bindings, for not a single nail or piece of metal enters into its composition. The wheel consists of two rims of unequal diameter, of which the one next the bank is rather the least. "This double wheel," observes Staunton, "is connected with the axis by sixteen or eighteen spokes of bamboo, obliquely inserted near each extremity of the axis, and crossing each other at about two-thirds of their length. They are there strengthened by a concentric circle, and fastened afterwards to the rims; the spokes inserted in the interior extremity of the axis (or that next to the bank,) reaching the outer rim, and those proceeding from the exterior extremity of the same axis reaching the inner and smaller rim. Between the rims and the crossings of the spokes is woven a kind of close basket-work, serving as ladle-boards," which are acted upon by the current of the stream, and turn the wheel round.

The whole diameter of the wheel being something greater than the height of the bank, about sixteen or twenty hollow bamboos, closed at one end, are fastened to the circumference, to act as buckets. These, however, are not loosely suspended, but firmly attached with their open mouths towards the inner or smaller rim

of the wheel, at such an inclination, that when dipping below the water their mouths are slightly raised from the horizontal position; as they rise through the air their position approaches the upright sufficiently near to keep a considerable portion of the contents within them; but, when they have reached the summit of the revolution, the mouths become enough depressed to pour the water into a large trough placed on a level with the bank to receive it. The impulse of the stream on the ladle-boards at the circumference of the wheel, with a radius of about fifteen feet, is sufficient to overcome the resistance arising from the difference of weight between the ascending and descending, or loaded and unloaded, sides of the wheel. This impulse is increased, if necessary, at the particular spot where each wheel is erected, by damming the stream, and even raising the level of the water where it turns the wheel. When the supply of water is not required over the adjoining fields, the trough is merely turned aside or removed, and the wheel continues its stately motion, the water from the tubes pouring back again down its sides. These wheels extend, on the river Kan-keang, from the neighborhood of the pass to a considerable distance down its stream towards the lake, and they were so numerous that we never saw less than thirty in a day. It is calculated that one of them will raise upwards of three hundred tons of water in the four-and-twenty hours. Viewed merely in regard to their object, the Persian wheel, and the machines used for raising water in the Tyrol, bear some resemblance to the one just described, but, as observed by Staunton, "they are vastly more expensive, less simple in construction, as well as less ingenious in contrivance."

Discovery of Gunpowder, and Inventions arising therefrom.

It is not known with accuracy at what time gunpowder was discovered. The Chinese were acquainted with it at a very early period. It was not until the beginning of the sixteenth century, one hundred and fifty years after the invention of cannon, that iron balls were used. Muskets were not used until the year 1521. The Spaniards first armed their foot soldiers in this manner. They used matchlocks: firelocks were not used until the beginning of the seventeenth century,—that is, one hundred and eighty years after muskets were invented. Even then, the great Marshal Saxe had so little confidence in the efficacy of a flint, that he ordered a matchlock to be added to the lock with a flint, lest the flint should miss fire: such is the force of habit on the human mind. Bayonets derive their name from the town of Bayonne, in France, where

they were introduced about 1673. They came in use among the English grenadiers in the reign of James the Second. Many such are yet to be seen in the small armory at the Tower of London. The use of them, fastened to the muzzle of the firelock, was also a French improvement, first adopted about 1690. It was accompanied in 1693, at the battle of Marseille, in Piedmont, by a dreadful slaughter, and its use universally adopted by the rest of Europe in the war of the succession.

A few Remarks on the Relation which subsists between a Machine and its Model.

The following remarks by Edward Sang, a teacher of mathematics in Edinburgh, are very interesting, as demonstrating the relation between a machine and its model,—a subject which is, perhaps, not generally well understood :—

" At first sight, a well-constructed model presents a perfect representation of the disposition and proportion of the parts of a machine, and of their mode of action.

" Misled by the alluring appearance, one is apt, without entering minutely into the inquiry, also to suppose that the performance of a model is, in all cases, commensurate with that of the machine which it is formed to represent. Ignorant of the inaccuracy of such an idea, too many of our ablest mechanicians and best workmen waste their time and abilities on contrivances which, though they perform well on the small scale, must, from their very nature, fail when enlarged. Were such people acquainted with the mode of computing the effects, or had they a knowledge of natural philosophy, sufficient to enable them to understand the basis on which such calculations are founded, we should see fewer crude and impracticable schemes prematurely thrust upon the attention of the public. This knowledge, however, they are too apt to regard as unimportant, or as difficult of attainment. They are startled by the absurd distinction which has been drawn between theory and practice, as if theory were other than a digest of the results of experience; or, if they overcome this prejudice, and resolve to dive into the arcana of philosophy, they are bewildered among names and signs, having begun the subject at the wrong end. That the attainment of such knowledge is attended with difficulty is certain, but it is with such difficulty only as can be overcome by properly directed application. It would be, indeed, preparing disappointment to buoy them up with the idea, that knowledge, even of the most trivial importance, can be acquired without labor.

Yet it may not be altogether unuseful, for the sake both of those who are already, and of those who are not, acquainted with these principles, to point out the more prominent causes, on account of which the performance of no model can, on any occasion, be considered as representative of that of the machine. Such a notice will have the effect of directing the attention, at least, to this important subject. In the present state of the arts, the expense of constructing a full-sized instrument is, in almost every instance, beyond what its projector would feel inclined, or even be able, to incur. The formation of a model is thus universally resorted to, as a prelude to the attempt on the large scale. An inquiry, then, into the relation which a model bears to the perfect instrument, can hardly fail to carry along with it the advantage of forming a tolerable guide, in estimating the real benefit which a contrivance is likely to confer upon society.

"In the following paper I propose to examine the effect of a change of scale on the strength and on the friction of machines, and, at the same time, to point out that adherence to the strictest principles which is apparent in all the works of nature, and of which I mean to avail myself in fortifying my argument.

"Previous, however, to entering on the subject-proper, it must be remarked that, when we enlarge the scale according to which any instrument is constructed, its surface and its bulk are enlarged in much higher ratios. If, for example, the linear dimensions of an instrument be all doubled, its surface will be increased four and its solidity eight-fold. Were the linear dimensions increased ten times, the superficies would be enlarged one hundred, and the solidity one thousand times. On these facts, the most important which geometry presents, my after-remarks are mostly to be founded.

"All machines consist of moveable parts, sliding or turning on others, which are bound together by bands, or supported by props. To the frame-work I shall first direct my attention.

"In the case of a simple prop, destined to sustain the mere weight of some part of the machine, the strength is estimated at so many hundred weights per square inch of cross section. Suppose that, in the model, the strength of the prop is sufficient for double the load put on it, and let us examine the effect of an enlargement, ten-fold, of the scale according to which the instrument is constructed. By such an enlargement, the strength of the prop would be augmented one hundred times; it would be able to bear two hundred loads such as that of the model, but then the weight to be put on it would be one thousand times that of the small machine, so that the prop in the large machine would be able to bear

only the fifth part of the load to be put on it. The machine, then, would fall to pieces by its own weight.

"Here we have one example of the erroneous manner in which a model represents the performance of a large instrument. The supports of small objects ought clearly to be smaller in proportion than the supports of large ones. Architects, to be sure, are accustomed to enlarge and to reduce in proportion; but nature, whose structures possess infinitely more symmetry, beauty, and variety, than those of which art can boast, is content to change her proportions at each change of size. Let us conceive an animal having the proportions of an elephant and only the size of a mouse; not only would the limbs of such an animal be too strong for it, they would also be so unwieldy that it would have no chance among the more nimble and better proportioned creatures of that size. Reverse the process, and enlarge the mouse to the size of an elephant, and its limbs, totally unable to sustain the weight of its immense body, would scarcely have strength to disturb its position even when recumbent.

"The very same remarks apply to that case in which the weight, instead of compressing, distends the support. The chains of Trinity Pier are computed to be able to bear nine times the load put on them. But if a similar structure were formed of ten times the linear dimensions, the strength of the new chain would be one hundred times the strength of that at Trinity, while the load put upon it would be one thousand times greater; so that the new structure would possess only nine-tenths of the strength necessary to support itself. Of how little importance, then, in bridge building, whether a model constructed on a scale of perhaps one to a hundred support its own weight! Yet, on such grounds, a proposition for throwing a bridge of two arches across the Forth, at Queensferry, was founded. Putting out of view the road-way and passengers altogether, the weight of the chain alone would have torn it to pieces. The larger species of spiders spin threads much thicker, in comparison with the thickness of their own bodies, than those spun by the smaller ones. And, as if sensible that the whole energies of their systems would be expended in the frequent reproduction of such massy webs, they choose the most secluded spots; while the smaller species, dreading no inconvenience from a frequent renewal of theirs, stretch them from branch to branch, and often from tree to tree. I have often been astonished at the prodigious lengths of these filaments, and have mused on the immense improvement which must take place in science, and in strength of materials too, ere we could, individually, undertake works of such comparative magnitude.

"When a beam gives support laterally, its strength is proportioned to its breadth, and to the square of its depth conjointly. If, then, such a beam were enlarged ten times in each of its linear dimensions, its ability to sustain a weight placed at its extremity would, on account of the increased distance from the point of insertion, be only one hundred times augmented, but the load to be put upon it would be one thousand times greater; and thus, although the parts of the model be quite strong enough, we cannot thence conclude that those of the enlarged machine will be so.

"It may thus be stated as a general principle, that, in similar machines, the strengths of the parts vary as the square, while the weights laid on them vary as the cube of the corresponding linear dimension.

"This fact cannot be too firmly fixed in the minds of machine makers; it ought to be taken into consideration even on the smallest change of scale, as it will always conduce either to the sufficiency or to the economy of a structure. To enlarge or diminish the parts of a machine all in the same proportion, is to commit a deliberate blunder. Let us compare the wing of an insect with that of a bird: enlarge a midge till its whole weight be equal to that of the sea-eagle, and, great as that enlargement must be, its wing will scarcely have attained the thickness of writing paper; the falcon would feel rather awkward with wings of such tenuity. The wings of a bird, even when idle, form a conspicuous part of the whole animal; but there are insects which unfold, from beneath two scarcely perceived covers, wings many times more extensive than the whole surface of their bodies.

"The larger animals are never supported laterally; their limbs are always in a position nearly vertical: as we descend in the scale of size the lateral support becomes more frequent, till we find whole tribes of insects resting on limbs laid almost horizontally. The slightest consideration will convince any one that lateral or horizontal limbs would be quite inadequate to support the weight of the larger animals. Conceive a spider to increase till his body weighed as much as that of a man, and then fancy one of us exhibiting feats of dexterity with such locomotive instruments as the spider would then possess!

"The objects which I have hitherto compared have been remote, that the comparisons might be the more striking; but the same principles may be exhibited by the contrast of species the most nearly allied, or of individuals even of the same species The larger species of spiders, for instance, rarely have their legs so much extended as the smaller ones; or, to take an example

from the larger animals, the form of the Shetland pony is very different from that of the London dray-horse.

"How interesting it is to compare the different animals, and to trace the gradual change of form which accompanies each increase of size! In the smaller animals, the strength is, as it were, redundant, and there is room for the display of the most elaborate ornament. How complex or how beautiful are the myriads of insects which float in the air, or which cluster on the foliage! Gradually the larger of these become more simple in their structure, their ornaments less profuse. The structure of the birds is simpler and more uniform, that of the quadrupeds still more so. As we approach the larger quadrupeds, ornament, and then elegance, disappear. This is the law in the works of nature, and this ought to be the law among the works of art.

"Among one class of animals, indeed, it may be said that this law is reversed. We have by no means a general classification of the fishes; but, among those with which we are acquainted, we do not perceive such a prodigious change of form Here, however, the animal has not to support its own weight; and whatever increase may take place in the size of the animal, a like increase takes place in the buoyancy of the fluid in which it swims. Many of the smaller aquatic animals exhibit the utmost simplicity of structure; but we know too little of the nature of their functions to draw any useful conclusions from this fact."

Shoes and Buckles.

The business of a shoemaker is of great antiquity. The instrument for cleaning hides, the shoemaker's bristle added to the yarn, and his knife, were in use as early as the twelfth century. He was accustomed to hawk his goods, and it is conjectured that there was a separate trade for annexing the soles. The Romans in classical times wore cork soles in their shoes, to secure the feet from water, especially in winter; and as high heels were not then introduced, the Roman ladies who wished to appear taller than they had been formed by nature, put plenty of cork under them. The streets of Rome in the time of Domitian were blocked up by cobbler's stalls, which he therefore caused to be removed. In the middle ages shoes were cleaned by washing with a sponge; and oil, soap, and grease were the substitutes for blacking. Buckles were worn on shoes in the fourteenth century. In an Irish abbey a human skeleton was found with marks of buckles on the shoes. In England they became fashionable many years before the reign

of Queen Mary; the laboring people wore them of copper; other persons had them of silver, or copper gilt; not long after, shoe roses came in. Buckles revived before the revolution of 1689, remained fashionable till after the French revolution in 1789, and finally became extinct before the close of the eighteenth century.

The Croton Aqueduct.

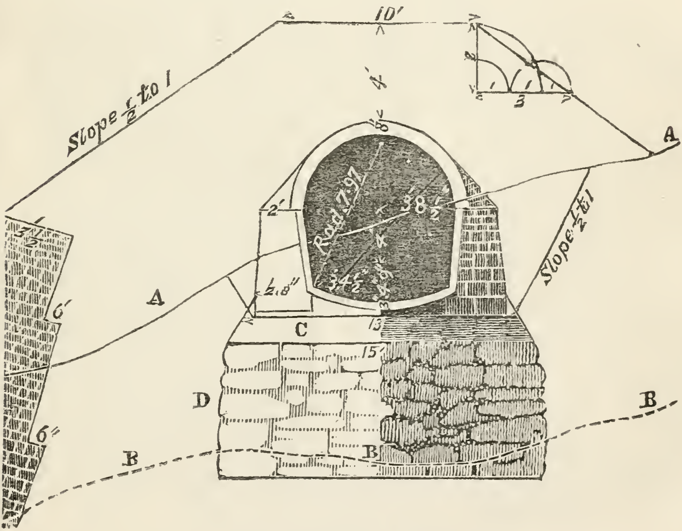
Some of our readers may have had their curiosity excited with respect to the great aqueduct now in construction for the supply of New York with water. The following description of the manner in which the work is performed, with the illustrative cut connected with it, will prove acceptable. We have been indebted for them to Mr. Miner, editor of the Railroad Journal, from whom we have before received several similar favors.

The ground on which New York stands consists chiefly of loose sand, intermixed in many places with coarse gravel and boulders, or roundish stones of different sizes, apparently brought by a flood of water from some primitive region. Hornblend rock predominates. Granite and gneiss rocks are found in original masses in some parts. Long Island consists of sand and loose stones, without a trace of any fixed rock, except at Hurlgate, and perhaps at one or two other places.

Primitive rocks and soils generally furnish good water; and the springs of this city, though few and public, are abundant, and many of them were originally good. The increase of population, however, has caused the deterioration of the water: for where the rain once fell on fields of grass or groves of wood, it now meets with crowded streets or narrow lots occupied by crowded habitations, and contracts impurities which it carries with it far down into the sands where the springs flow. Some of the wells in the middle and upper parts of the city, which yielded excellent water within the memory of living inhabitants, have become so much affected in later years, that many of the people purchase drinking water at a penny a pailful, of men who bring it in carts from springs yet untainted by the encroaching city. As the water of the wells is unfit for washing as well as for drinking, every family requires a cistern; and thus it has been thought desirable, for many years, that an abundant supply of good water should be obtained for the city.

The Water Works in Chambers street, under the direction of the Manhattan Company, have furnished, for some years, water of an inferior quality to the inhabitants of many streets in the lower

parts of the city, at certain prices; and water for the use of fire-engines has since been provided, in a large reservoir on the height of ground, from which it is distributed in hydrants to different districts. It was proposed, some years ago, to obtain a supply from several ponds in the town of Rye: but, after an examination, the Croton river was preferred, although the distance was great, the route obstructed by serious impediments, and the work tedious and very expensive. The friends of the enterprise, however rightly judged, that nothing could be so expensive to the health and convenience of the inhabitants, and therefore in fact so great a pecuniary loss to the city treasury, as the longer neglect of the great work. It was therefore commenced; and about five thousand men have sometimes been employed on it at one time.—*Family Visiter.*



Section of the Croton Aqueduct.

Description of the mode of constructing the Croton Aqueduct, from the American Railroad Journal.—The materials used are good building-stone, of the proper degree of hardness and durability, free from all metals, particularly iron. Gneiss is preferred to any other, both because it is more plentiful and more easily worked. Some limestone is also used, but not until it has the

express permit of the Resident Engineer. Brick is the next material; it is required to be from the centre of the kiln, such as is thoroughly burnt, free from lime or any other impurity, and to possess a clear ringing sound when struck. The worst accepted are such as cost from five to seven dollars a thousand. Next is the cement, from which the concrete and masonry generally are formed. The commissioners' specifications are very explicit relative to the manufacture of this article, requiring that the name of the manufacturer should be known; that the cement shall not have been made more than six months before being used; that it shall be transported from the factory in water-tight casks; and, in addition to all this, that each parcel or cargo received shall be thoroughly tested, either by officers appointed for the purpose, or by the Resident Engineer himself. These are the principal materials, stone, brick, and cement. The stone is required to be always clean, and in hot weather, kept wet, and when laid in the wall requiring mortar, it must "swim" in the cement—that is, when the stone is lifted up from its bed, no point or surface of the stone must touch the stone below it, each stone must be surrounded by cement. When the weather is hot, the top of the wall must be kept moist, and in cold weather all the masonry must be covered so effectually, as to protect it perfectly. The brick must be laid true and even, allowing three-eighths of an inch joint, or thereabouts. In hot weather, they are to be soaked in water, and to be kept wet while being laid. The cement is mixed in different proportions, according to the work required. For stone work, the proportions are one part of cement to three of sand, (the sand to be medium size, sharp grained and clean—river sand is accepted.) For brick work, the proportions are one of cement to two of sand; for concrete, one part of cement, three of sand, and three of clean building-stone, broken about as fine as that used for Macadamizing. Concrete is used for forming artificial foundations, is mixed with as little water as possible, and when laid in any part of the work, is left undisturbed forty-eight hours; at the expiration of this time it has become so hard, that a blow with a pickaxe will not break it: it becomes quite a rock.

The aqueduct, maintaining a uniform descent, requires that in places the earth should be cut away, and in crossing valleys, that they should be filled up. In the former case, the sides of the cut are left standing at a slope of one half to one; that is, if the perpendicular height of the side of the cut be six feet, it will fall from directly above its base three feet. It is one-half horizontal to one vertical. The base of the cut is always thirteen feet wide. Pegs, showing the bottom of the side walls, and of the reversed arch in

brick, are given by the engineers, who, at the same time, determine the centres, if necessary, from these data. The builder lays a small layer of concrete, at least three inches, whose top shall be as high as the top of the peg just set. On the concrete he proceeds to build the side walls of the aqueduct. You may see the dimensions by the plan better than I could tell you. The side walls being done, they are filled in behind them, up to the top, with earth, to prevent strain or damage, also to act as a support, and cover up the work as fast as possible. Then the concrete is laid for the bottom of the reversed arch in brick, by means of moulds placed every ten feet apart. When thoroughly set, the brick work is commenced. Selecting the best brick (and it has all been most thoroughly inspected,) the reversed arch is laid, and then the "brick-facing"—that is, facing the inside of the wall with brick, when carried up to the top of the wall. The upper arch, consisting of two ring courses (with occasional headers,) is thrown; the arch is covered with a thick coating of plaster, and the angle made by the top of the wall and arch filled with the same kind of masonry as the side walls; and then the aqueduct is done.

You will perceive it to be a long brick vault stretching from New York to Croton, ascending at the rate of thirteen inches in a mile. The earth removed in the excavation is then "back filled" over the aqueduct until it is four feet deep over the crown of the arch, level on top, and ten or eight feet wide, and the sides slope one and a half to one, (as you see in the figure.) When the ground is too steep, a "protection wall" is introduced, (see drawing;) this is laid dry, i. e., without mortar, and made to slope one half to one, as in the drawing, or one to one, at an angle of forty-five degrees. So much for the aqueduct "in open cutting in earth." When a valley is crossed, a heavy wall fifteen feet wide on top, with sides sloping one-twelfth to one, must be built. They are large stones firmly imbedded in small broken ones. On the top of this wall, a foot of concrete is placed; the aqueduct, as usual, is built on that. As water passes through valleys, a stone passage way, called "a culvert," is made of suitable dimensions.

Cugnot's Steam Carriage.

The improvements of the mechanism of the steam engine, stimulated many projects for adapting its agency to other purposes besides that of raising water; and the scheme of John Theophilus Cugnot, a native of Void, in Lorraine, is meritorious for its novelty and its successful practical development. In his youth, Cugnot served in Germany as an engineer. Passing after-

wards into the service of Prince Charles of Lorraine, he resided at Brussels, and gave lessons in the military art, with the theory and practice of which he was profoundly acquainted. The invention of a light gun procured him the notice of the Compte de Saxe, to whom, about 1763, he exhibited a model of a carriage moved by a steam engine, instead of horses. He afterwards lived at Paris, and through the recommendation of the Compte, obtained, in 1769, the patronage of the Duc de Choiseul, then minister at war. He was now enabled, at the public expense, to construct a large carriage moved by a steam engine, similar to that of the model he had shown years previously. At the first trials in 1770 of this novel vehicle, before a numerous assemblage of officers and professional persons, its movements were so violent as to overturn a portion of a wall that was opposed to its progress. This, unfortunately, produced an opinion, that in consequence of the uncertainty of obtaining proper mechanical control, its motion would be of small use in practice. The project was therefore abandoned, and the experimental machine was deposited in the museum of the Arsenal, to become a point of reference to the epigrammatist, and a memorial of the blasted hopes of the accomplished author. Cugnot's genius expanded half a century too soon, either for its value being known, or its efforts cherished.

At a later period of life, his means of subsistence having fallen into decay, the various services he had rendered to the public were thought to entitle him to a reward from the state. The revolution sweeping away even this pitiful pension of twenty-one pounds a year, Cugnot must have perished with hunger, but for the compassionate benevolence of a lady of Brussels. With the kindness of her sex, she not only provided for the wants, but watched with tenderness over the personal comforts of the now feeble and helpless old man, until the well known Mercier succeeded in drawing the attention of Napoleon to the miserable fate of his aged and ancient friend.

Cugnot died at Paris in 1805, in his 80th year, in a state to him of comparative affluence, from the enjoyment of a valuable annuity from Napoleon.

Eloquent Description

But about seventy years since, every thread used in the manufacture of cotton, wool, worsted, and flax, throughout the world, was spun singly by the fingers of the spinner, with the aid of that *classical instrument*, the domestic spinning wheel. In 1767, an *eight-handed* spinster sprung from the genius of Hargreaves;

and the *jenny*, with still increasing powers, made its way into common use in spite of all opposition. Two years afterwards the more wonderful invention of Wyatt, which claims a much earlier origin, but which had disappeared, like a river that sinks into a subterraneous channel, now rose again under the fortunate star of Arkwright, claiming yet higher admiration, as founded on principles of more extensive application. Five years later the happy thought of *combining* the principles of these two inventions, to produce a third, much more efficient than either, struck the mind of Crompton, who, by a perfectly original contrivance, effected the union. From twenty spindles this machine was brought, by more finished mechanism, to admit of a hundred spindles, and thus to exercise a Briarean power. Kelly relinquished the toilsome method of turning the machine by hand, and yoked to it the strength of a rapid river. Watt, with the subtler and more potent agency of steam, moved an iron arm that never slackens or tires, which whirls round two thousand spindles in a single machine. Finally, to consummate the wonder, Roberts dismisses the spinner, and leaves the machine to its own infallible guidance. So that at the present time several thousand spindles may be seen in a single room, revolving with inconceivable rapidity, with no hand to urge their progress, or to guide their operations—drawing out, twisting, and winding up as many thousand threads with unfailing precision, indefatigable patience and strength,—a scene as magical to the eye that is not familiar to it, as the effects have been marvellous in augmenting wealth and population.

If the thought should cross any mind, that, after all, the genius of man has been expended in the insignificant object of enabling men better to pick out, arrange, and twist together the fibres of a vegetable wool,—that it is for the performance of this minute operation that so many energies have been exhausted,—so much capital employed,—such stupendous structures reared, and so vast a population trained up—we reply: An object is not insignificant because the operation by which it is effected is *minute*: the first want of men in this life, after food, is *clothing*, and as this *art* enables them to supply it far more easily and cheaply than the old methods of manufacturing, and to bring cloths of great elegance and durability within the use of the humble classes, it is an art whose utility is only inferior to that of agriculture. It is almost impossible to over-estimate the importance of these inventions. The Greeks would have elevated their authors among the gods; nor will the enlightened judgment of modern times deny them the place among their fellow men, which is so undeniably their due.

A Watchmaker's Epitaph.

The following *professional* epitaph is copied from a tombstone in Lidford Churchyard, Devon, England.

Here lies in horizontal position
The "outside case" of
George Routleigh, Watch Maker,
Whose abilities in that line were an honor
To his Profession.
Integrity was the "Main-spring,"
And Prudence the "Regulator" of all the
Actions of his Life.
Humane, generous, and liberal,
His "Hand" never stopped
Till he had relieved distress.
So sincerely "regulated" were all his movements,
That he never "went wrong,"
Except when "set agoing"
By People
Who did not know
"His Key."
Even then he was easily
"Set right" again.
He had the Art of disposing his "Time"
So well,
That his "hours" glided away
In one continual round
Of Pleasure and Delight,
Till an unlucky Moment put a period to
His Existence.
He departed this Life,
November 14th, 1802,
Aged 57 :
"Wound up"
In hopes of being "taken in Hand"
By his Maker,
And of being
Thoroughly "cleaned,"—"repaired,"—and "set agoing"
In the World to come